Volume I, No. 9 SEPTEMBER, 1919 OLD SERIES, Vol. XVII, No. 9

SEP 25 1919
UNIV. OF MICH.

The Journal of Orthopædic Surgery

The Official Publication of the
American Orthopedic Association
and of the
British Orthopaedic Association

PUBLISHED ON THE FIFTH DAY OF EACH MONTH AT LINCOLN, NEBRASKA, U. S. A.
FOUR DOLLARS PER ANNUM
Entered as Second Class Matter in the Post Office at Lincoln, Nebraska

For the
British Orthopædic Association
Editor
R. C. ELMSLIE, M. S., F. R. C. S.
Editorial Committee
T. R. ARMOUR, F. R. C. S.
W. H. TRETHOWAN, F. R. C. S.
H. PLATT, M. S., F. R. C. S.

For the
American Orthopedic Association
Editor
H. WINNETT ORR, M. D., F. A. C. S.
Editorial Committee
MARK H. ROGERS, M. D., F. A. C. S.
E. W. RYERSON, M. D., F. A. C. S.
J. TORRANCE RUGH, M. D.

ORIGINAL ARTICLES.—Papers for publication will be accepted only for exclusive publication in this Journal. Papers in foreign languages will be accepted and translated without charge, if suitable for publication. The American Orthopedic Association and the British Orthopædic Association do not officially endorse the opinions presented in the different papers published in this Journal.

Papers for publication and all other communications for the Editorial Department should be addressed in England to R. C. Elmslie, M. S., F. R. C. S., 1a., Portland Place, London, W. 1; in America to H. Winnett Orr, M. D., Lincoln, Nebraska.

CURRENT ORTHOPÆDIC LITERATURE.—Contributions for this department should be sent H. Winnett Orr, M. D., Lincoln, Nebraska.

REFUSED MANUSCRIPTS will be returned provided stamps are forwarded for that purpose.

ADVERTISEMENT.—Advertising forms go to press on the fifth of the month preceding the month of issue. Advertising rates will be furnished on application.

CHANGE OF ADDRESS.—When address is to be changed, both the old and new addresses should be given.

THE SUBSCRIPTION PRICE of this Journal is $4.00 per year, in advance, postage prepaid for the United States and Mexico; the equivalent of $4.50, or 18 shillings, for all foreign countries included in the postal union. Canada, $4.25. Single copies, 40 cents.

All communications concerning subscription and advertising should be addressed to the Publisher, and all checks, drafts and post-office orders should be made payable to

THE JOURNAL OF ORTHOPAEDIC SURGERY
Lincoln, Nebraska, U. S. A.

ROBERT LINDER

Manufacturers of

Orthopedic Appliances

Hip Splints, Arm Splints, Knee Splints,
Bow-Leg Braces, Knock-Knee Braces,
Spine and Shoulder Braces,
and Flat-Foot Soles

ELASTIC STOCKINGS and TRUSSES
of every description

No. 148 East 53rd Street, New York

Contents For September, 1919

Author and Subject Index

Author and Subject	Page
Ankle, Wounds of—Chutro	521
Arthritis Suppurative Treatment —Everidge	583
Baetjer, F. H.—Osteomyelitis	573
Bennett, Geo. E.—Lengthening of Quadriceps	530
Bernstein, A. M., Tendon Surgery	591
Blake, Joseph A., Influence of the War Upon Surgery	576
Bowlegs, Non-Union After Operation for—Geist	527
Bradford, E. H. Spinal Curvature	587
Buchbinder, J. R., Gun-Shot Fractures of Femur	589
Bulkley, Kenneth, Femur Fractures	575
Chutro, Infected Wounds	521
Davis Gwilym G., An Appreciation —Rugh	570
Everidge, J., Treatment of Suppurature Arthritis	583
Extremities, Bone Surgery of—Thompson	586
Femur, Fracture, Gun-Shot—Buchbinder	589
Femur, Fracture of—Bulkley, Sinclair	575
Flail Joint After Resection—Tavernier and Jalifer	592
Foot Muscles—Merrill	562
Fracture, Femur—Bulkley-Sinclair	575
Fracture, Femur, Gun-Shot—Buchbinder	589
Fractures, Ununited Treatment—Kidner	549
Geist, Emil, Non Union After Osteotomy	527
Hip, Gun-Shot Wounds of—Mayer, Leo	590
Jalifer and Tavernier, Flail Joint After Resection	592
Joint Resection, Flail Joint—Tavernier and Jalifer	592
Joints, Gun-Shot Wounds, Infections—Mollenhauer and Mayer	590
Kidner, F. C., Ununited Fractures	549
Knee-Suppuration of Treatment—Everidge	583
Lovett, R. W., Tribute to Dr. H. Augustus Wilson	569
Mayer, Leo, Gun-Shot Wounds of the Hip	590
Mayer, Leo, and Mollenhauer, Gun-Shot Wounds of Joints	590
Merrill, W. J., The Pedal Groups	562
Mollenhauer, Paul, and Mayer, Gun-Shot Wounds of Joints	590
Non-Union After Osteotomy—Geist	527
Non-Union, Treatment—Kidner	549
Osteomyelitis, Baetjer	573
Pedal Groups—Merrill	562
Quadriceps, Lengthening of—Bennett	530
Rugh, J. T., an Appreciation of Dr. G. G. Davis	570
Sinclair, Donald B., Femur Fractures	575
Spine, Curvature of, Brace For—Truslow	547
Spine, Curvature of—Bradford	587
Surgery, Influence of the War Upon—Blake	576
Surgical Anatomy, Bones of Extremities—Thompson	586
Tavernier, L., and Jalifer, Flail Joints After Resection	592
Tendon Transference Technique—Bernstein	591
Thompson, J. A., Surgical Approach Bones of Extremities	586
Truslow, Walter E., Scoliosis Brace	547
Wilson H. Augustus, An Appreciation—Lovett	569
Wounds, Infected—Chutro	521

Athenia Corsets

for

Spinal and Abdominal Support

Made on natural lines to fit the average normal figure. Designed with the help and advice of eminent physicians to give support to the natural curve of the spine and abdomen without pressure at the waist or diaphragm.

As no corset will fit every figure, adjustments and alterations are often necessary and should be made under our supervision. For cases where this is impossible, we have prepared careful directions to insure proper fitting.

MANUFACTURED AND SOLD AT

Chandler's Corset Store

Established 1897

50 Temple Place **Boston**

The Management of an Infant's Diet

DIARRHEA

The importance of nourishment in intestinal disturbances that are so common during the warm weather is now recognized by physicians, and it is also appreciated that the nutrition furnished must be somewhat different than the milk modification usually supplied to the normal infant.

Food elements that seem to be particularly well adapted, mixtures that are suitable to meet the usual conditions, and the general management of the diet, are described in our pamphlet—"The Feeding of Infants in Diarrhea"—a copy of which will be sent to any physician who desires to become familiar with a rational procedure in summer diarrhea.

Mellin's Food Company, **Boston, Mass.**

Vol. I, No. 9 SEPTEMBER, 1919 Old Series: Vol. vxii, No. 9

The Journal of Orthopædic Surgery

INFECTED WOUNDS OF THE ANKLE

BY P. CHUTRO OF PARIS.

In a recent communication in the Journal de Chirurgie de Paris, I described the technique and the indications for treatment of lesions of the ankle.

Upon the request of several colleagues, I have permitted myself to present before you the same subject.

Theoretically, I retain certain doubts as to the efficacy of the treatment of Willems for lesions of the ankle, especially when the arthritis is accompanied by a fracture, which is frequently the case in war wounds.

According to my personal experience, the treatment of Willems is admirable when there is no grave fracture of one of the important bones of the articulation.

The astragalus is adapted so exactly to the mortise that except in certain fractures by rifle-ball, all fractures of this bone give rise to a deformity which renders the movement of the joint very difficult. Again, it is not uncommon that several of the elements of the joint have been injured by the projectile. In this case, the fragments of bone, and especially those of cartilage, form a veritable partition of the synovial membrane, and they contribute to the retention of pus.

These facts, together with the facility with which the infection of the joint invades the neighboring tendon sheaths, impose the indication for the operation of astragalectomy, from the very first, in order to suitably drain the ankle-joint. All opinions seem to be in accord on this subject.

But the treatment does not always seem to give the desired result, and numerous amputations have been done long after the

primary operation, in order to obviate not only the phenomena of infection, but phenomena of another order, of which I will give a brief resume.

The alarming symptoms of the infection subside immediately after the astragalectomy, but at the end of several days, or of several weeks, one observes that the foot remains very swollen, that the wound shows exuberant granulations, and that it bleeds very easily. All movement becomes impossible at this time on account of pain, and also because of a true mechanical hindrance.

If one examines the patient several weeks later, it is seen that although the wound is closing well, the foot remains swollen, with a chronic oedema which obliterates all the normal outlines. The retro-malleolar depressions are effaced, the toes are immobile and contracted, the sole is round, that is to say convex, the foot tends to the equinus position, and the patient is entirely incapable of using it. Sometimes the lesion is painful, and the foot is affected with tactile hypersensibility, and alterations in the temperature and the color.

All this group of disabilities bring the surgeon and the patient to the conclusion of the necessity of an amputation which could have been avoided in a great majority of the cases.

What is the reason of all these difficulties?

I have already said that the infection itself counts for very little, because after astragalectomy there is drainage under good conditions; and although certain cases still retain neighboring fragments of bone in process of elimination, this fact alone would not account for the symptoms which have just been enumerated.

The most plausible explanation is the following: after astragalectomy has been done, the foot is generally immobilised at a right angle in one of the numerous appliances which have been employed during these past years. These appliances retain the foot well at a right angle, but they do not adapt themselves to the special conformation of the inferior part of the leg and of the posterior half of the foot. In reality, they are appliances which only serve to give a bearing point to the heel.

While the member is immobilised in this way, the bones of the leg drop backward; the mortise, which is no longer retained in place by any ligament, comes to be applied to the non-articular portion of the superior surface of the os calcis, at the same time that

the whole foot undergoes a dislocation forward. The consequences of this displacement of the bones of the leg backward, or of the dislocation of the foot forward (according to the manner in which one wishes to consider this movement) are of several kinds:

(1) A disappearance of the retromalleolar spaces is brought about, the tendon of Achilles coming closer to the bones of the leg.

(2) The border of the mortise, displaced backward, causes traction upon the flexor of the great toe, and then upon the common flexor of the toes, giving rise to a flexor contracture of the toes, and a plantar flexion of the fore part of the foot. The day that the patient abandons his apparatus, this same contraction of the toes will conduce markedly to the equinus deformity.

(3) The same tension produced by the mortise on the tendons acts also on the posterior vasculo-nervous bundles. The circulatory embarrassment is aggravated by the compression of the vessels, due to the disappearance of the retromalleolar spaces. The return circulation suffers especially, and the foot presents the signs of a permanent passive hyperemia, with cyanosis, sweating, and variations in the local temperature.

(4) The change in the position of the foot, and especially the change in the point of contact of the mortise, results in the os calcis, whose anterior part is normally elevated from 11 to 19 degrees, becoming completely horizontal, even coming in certain cases to present its posterior portion higher than its anterior apophysis.

All these lesions may be still further aggravated by lateral displacements at the level of the ankle. At the same time, the contraction of the tendon of Achilles is accentuated little by little, by the fact that the points of insertion are closer together.

When the vicious attitude has not been corrected in the early stages, the deformity becomes fixed, and the correction is very difficult. Sometimes, under anaesthesia, and after tenotomy of the Achilles tendon, the foot can be brought back to a suitable position. An ultimate treatment of massage, hot air, active mobilisation and re-education may complete the cure. In other cases, an orthopedic amputation may be counselled. When we have been obliged to resort to amputation we have employed osteoplastic methods with excellent results.

Before ending this resume of explanation, permit me to explain to you the manner in which our patients have been operated and treated in order to avoid all these unpleasant results.

In addition to cleaning the wounds of entrance and exit, we perform an incision in the form of an italic "S", commencing above the external malleolus and descending along the anterior aspect of the malleolus to the line of the ankle joint, becoming then almost transverse as far as the prominence of the tendon of the tibialis anticus, then becoming again longitudinal and descending 2 or 3 centimetres. An astragalectomy is done, and when the cleaning of the wound has been done, the foot is fixed in good position.

In order to fix the foot, one passes a bronze wire through the skin and soft parts of the inferior lip of the wound: this wire grazed the posterior superior border of the cuboid, and then following a recurrent path, it traverses the anterior border of the external malleolus and the soft parts of the other lip of the wound. The necessary drainage tubes were placed, and the wire twisted. This partial closure of the wound never presented any ill consequences, because there remained always a large opening, well exposed, which permitted the discharge of pus and liquids.

When the infection had spread to the sheaths of the posterointernal tendons, one added a debridement which extended to the joint.

The advantages of this fixation by bronze wire are the following:

(1) The cuboid is brought close to the external malleolus.

(2) The tarsus is projected backward.

(3) The anterior portion of the os calcis retains its normal elevation above the horizontal plane, and flat foot is avoided.

(4) The retromalleolar spaces become deeper than normal.

(5) There is no traction on the posterior tendons, nor compression of the vessels.

(6) The Achilles tendon is not shortened, and there is in consequence less probability of equinus deformity.

(7) The mortise, which is concave, rests above the articular surface of the os calcis, which is also concave: there remains, between the two, a cavity which will later be filled with a fibrous tissue, which will prevent bony anchylosis and will permit a certain mobility of the foot.

(8) The anterior tendons having their points of insertion nearer each other will gain in force and will contribute to the prevention of equinus.

The operation finished, the foot is immobilised at a right angle by a figure-of-eight bandage, extending from the heads of the metatarsals to the inferior ¼ of the leg.

In order to obtain a complete immobilisation, we were accustomed to apply an initial bandage as we have just said, and over this bandage there was added a second pad of cotton, very thick, and a new bandage is applied. The foot remains thus more immobile than in an apparatus.

The dressings were renewed at very long intervals, every 15 or 20 days. The bronze wire was removed about the fifth week. The patient commenced to walk on his foot between the fourth and fifth week, without crutch or cane; during the first days he was permitted to lean upon a chair or upon a comrade, but at the end of some days he walked alone.

It is unnecessary to wait until the wound is healed in order to have the patient walk. During some time, there was observed a little oedema of the foot, which bothered otherwise very little. It is always wise to advise the patient to stop after some minutes and raise his leg so as to aid the return circulation.

The results which we have obtained in this way, in war wounds as well as with patients in civil practice, are very satisfactory. The shortening is negligible almost, and when the patient retains a little mobility at the level of the ankle, he comes to walk without limping, and without one perceiving the disability existing at the level of the operated region.

Discussion.

Dr. Clarence L. Starr of Toronto said that the question of tarsal injuries and injury to the astragalus was one of intense interest, because all shell injuries to the foot followed by sepsis appeared hopeless as to final result. Most men thought the foot should be sacrificed and a stump made. Dr. Chutro had avoided this in injuries to the actragalus. Extensive tarsal injury made a very poor functionating foot. The astragalectomy under aseptic conditions in civil life, which is known as the Whitman operation, has given the only data upon which to base ideas of the functioning of the foot. Removal of the astragalus provided adequate drainage and displacing the foot backwards made a better weight bearing apparatus than any type of amputation. Dr. Chutro was to be congratulated upon the work he had done along the lines of the tarsus injuries.

Dr. Clarence L. Starr of Toronto said that he thought he agreed with Prof. Chutro, that the faults of the surgeon should not be blamed on Dakin's solution. There were some men who thought that Dakin's solution would do the entire thing. This was not enough but the personal touch of the surgeon with the patient should be followed through the course of after treatment. Professor Chutro had covered such a large field that it was impossible to discuss all the points. He would like to emphasize a few details: One was the acute character of the osteomyelitis; efficient drainage must be maintained until we reach

the stage in which the acute infection was eliminated; sequestra were usually formed, but it was better to let them alone until they separated, and then with their removal often the sinus was eliminated; secondly there were two things that kept a sinus open; foreign bodies, and a non-callapsible wall. The cavity might not go through the bone entirely, but with collapse of the wall, the sinus would disappear. In some cases a small sinus might open into a larger cavity; the cavity would never close until it was collapsed. One could excise the soft tissue and fibrous tissue wall, then reverse the cavity, by turning it inside out, bringing the wide portion to the outside and the narrow portion inside. Professor Chutro said one did not have bone formation from the bone itself. There was, however, a granulation tissue which became ossified and the cavity became filled to a large extent. In bone operations of that sort, it had been the experience of many, any of the speaker himself to see men treating a sinus from one of those two conditions, and without enlargement of the incision, trying to scoop out the cavity in a bleeding field, and so missing a foreign body, and causing a larger cavity. With a cavity of that sort, one should put on a tourniquet, then make an adequate incision and take out the foreign body, do a light curettage of the surface to get rid of dirty slough and granulation. This avoided tissue sepsis. The speaker said he had had large openings in the upper end of the tibia and had fully removed one side of it. This collapsed the cavity with satisfactory results. Attempts at transplanting muscle into the bone cavity below the knee joint had not been wholly satisfactory. One was never sure of filling the cavity entirely.

"NON-UNION FOLLOWING CORRECTIVE OSTEOTOMY OF THE TIBIA."

BY EMIL S. GEIST, M. D., F. A. C. S., MINNEAPOLIS, MINNESOTA.

Of the following two cases of operation on deformed tibiae which resulted in non-union, one occurred in my own work, while the other occurred in the practice of a Minneapolis surgeon. The latter case came to me for treatment of the bilateral un-united fracture. I deem it worth while to make a short report of these two cases as this is an operation which is frequently done without thought of the possible occurrence of any disastrous result.

The first case, the one which occurred in my own practice, was a healthy boy, two and one-half years old, who was born with a congenital unilateral deformity of the leg. The deformity was one of anterior bowing of the tibia at about its lower third combined with a moderate degree of inward bending (crus varus). Corrective brace was advised against as the bone was firm and inelastic. There existed no rickets.

On performing osteomoclasis, the bone was found to be quite sclerotic. Plaster was applied from toes to groin with leg in good position and the wound healed by first intention. On removing cast eight or nine weeks later, "delayed union" was found to exist, whereupon another similar cast was applied and worn for a term of two months. On removal of this, there still existed, as we hopefully termed it, "delayed union." A third similar cast was applied and the child allowed to put weight on the leg. X-ray at this time showed good apposition of fragments and some beginning absorption of the bone ends. Following removal of the third cast, there still existed no union. In the meantime, all laboratory tests, as Wassermann, etc., were made—all of them with negative results. Glandular extracts were injected with hope of cure and likewise negative results. After removal of the third cast, the leg was in good position, but there still existed non-union. Following this, a brace, well immobilizing the leg from toe to groin, was applied and the leg was kept under observation, for the following nine months, during which time X-rays showed progressive conical absorption of the bone ends. One and one-fourth year after operation, an Albee inlay operation was performed. Primary healing, but its end result was non-union.

At the expiration of another nine or ten months, another Albee inlay graft operation was done—this time by Ryerson, of Chicago, and myself. End result of this second bone graft operation is again failure of union.

Today the boy (who is now seven and one-half years old) has a straight leg, ununited, which he is using with a brace.

The second case occurred in a man thirty years old who "wished to have his bowlegs straightened so that he could get into the army." An operation was performed in November, 1917, by a surgeon who tells me that the bone was divided at the angle of deformity by means of a hand-saw. Healing was "per priman" in the right leg while there occurred an infection of moderate degree in the incision of the left leg, which infection cleared up fairly promptly under proper treatment.

In both legs, however, complete non-union supervened and the patient reported to me for the first time on February 17th, 1919, in the deplorable condition of having un-united fractures of both tibiae. Otherwise, he was an absolutely healthy young man with a negative Wassermann. He had been a good athlete before his surgical experience.

On February 19th, 1919, a typical Albee sliding graft operation was done on the right tibia which I am glad to say is entirely successful. On May 6th, 1919, the left leg was operated upon in a similar manner. As yet, it is too early to report on this.

These cases bring up the subject of non-union which I do not wish to discuss excepting to state that our knowledge regarding it is still far from complete. These two cases illustrate how we can obtain non-union in fractured bone where we have no interposition of foreign tissues and no constitutional disorders which we can recognize. I have observed from the beginning a case of simple linear fracture without displacement and which was well treated, in a healthy young farmer, which resulted in typical non-union and nearthrosis. I sometimes wonder whether there exists in some persons an idiosyncracy of their young osteoblasts toward the X-ray.

DISCUSSION.

DR. J. TORRENCE RUGH of Philadelphia, said he had had 3 non-unions following corrective osteotomies, one in a feeble minded child with thyroid condition; non-union persisted in spite of glandular extracts. At the end of 2 weeks when the stitches were taken out the flaps fell wide apart; there was no union of the soft parts. Idiosyncracy was a term to cover ignorance. Experience lent sup-

port to the idea that the internal secretions were at fault. In many cases the administration of glandular extracts would stimulate bony growth and secure firm union. This was a fruitful field for further investigation, because of the dire results which followed failure in these operations.

DR. S. L. MCCURDY, Pittsburgh, Pa., said that in some cases the pull of the fibula prevented the fractured ends of the tibia coming together, by the swing of the tibia over the fibula. He would like to know how Dr. Geist cut his bone. Union could sometimes be secured by making a very long oblique cut through the bone. Where the fragments were kept apart by an angular position, it was necessary to shorten the fibula. It might be found to be a question of mechanics rather than nutrition. A bone plate to make a bridge and lift into straight line would help, as in fracture of the radius of the forearm.

DR. J. TORRANCE RUGH of Philadelphia said he had shortened the fibula and got good union in the ends, but less than a year afterwards there was complete absorption at the site and then there was non-union of both bones.

DR. H. P. H. GALLOWAY of Winnipeg, said he had had two such cases, one in a young child, and he finally came to the conclusion that there was a congenital psuedarthrosis present which had not been recognized. Another was in an officer, 26 years of age, discharged from service, and who wanted his bow legs corrected. Union was very slow after operation, at the end of several months the man was able to walk, but still had the plaster cast. Dr. Geist had mentioned that his osteotomy was performed with a hand saw; possibly this was the cause of the non-union as the osteoblasts had probably been destroyed by the heat generated by the saw. The osteotomy should be done with a chisel and not a saw; somewhat more traumatism resulted, but this was advantageous as regards subsequent union. It was a good plan to scarify the shaft of the bone in the neighborhood of the osteotomy.

DR. J. D. GRIFFITHS of Kansas City said the lower third of the tibia was the hardest part to get union because of the poor blood supply. One should remember that metabolism had much to do with the question. Dr. Rugh had sounded a toosin that there was endocrinal disturbance. The speaker said he had found there was thymus disturbance with low blood pressure in long delayed union of the tibia, where there was no evidence of syphilis or tuberculosis. Glycerophosphates would be found to have an influence and in cases with low blood pressure, pituitary could be used.

DR. W. TRUSLOW of Brooklyn, said that in a case he had treated of a bow-legged child of 4 years old, no union was obtained after open osteotomy. The family doctor suggested a shot-gun prescription, including calcium phosphates. Bony union promptly followed its use.

DR. JOHN RIDLON of Chicago, said he was connected with the Home for Crippled Children for 20 years, and he had not had any cases of non-union from osteoclasis during that time. Some years ago a widow had come to consult him, bringing a child with bow legs. She wanted to marry a rich husband, but thought that the bow-legged child would interfere with the match. The speaker said he broke the child's legs with 6 fractures, and in four weeks the child had firm union of the bones and in 5 weeks he had a step father.

DR. EMIL GEIST, in closing said that he supposed he had reported something extremely rare, but apparently it was not so.

DR. R. HAMMOND, Providence, R. I., said that he had had one such case, in a colored child. At the end of three months there was non-union at the site of the fracture, although the bone was in perfect position. There was evidence of bone atrophy. During the operation under light anesthesia the child died, and it was thought probable that there was disturbance of the endocrinal system.

PRELIMINARY REPORT OF LENGTHENING OF THE QUADRICEPS TENDON.

BY GEORGE E. BENNETT, ASSOCIATE IN CLINICAL ORTHOPEDIC SURGERY JOHNS HOPKINS MEDICAL SCHOOL.

Loss of flexion of the knee joint following trauma or inflammatory lesions of the femur, and involving its adjacent structures, has been seen frequently enough to suggest its consideration as a problem in surgery.

Nearly everyone engaged in extremity surgery has seen quite frequently, as the end result of a fracture or inflammatory disease of the middle or lower third of the femur, a healed wound with no damage to the knee joint, but with a permanent loss of complete or partial flexion of the knee, due to adhesions or contractions of the muscles of the thigh. Feeling that the muscles forming the tendon of the quadriceps femoris were the structures at fault in this type of case, we have operated upon and lengthened the same with results that we believe justify the publishing of this preliminary report.

In order that the subject may be considered in an orderly and concise manner, we shall attempt to divide it into four sections. First, anatomical consideration; second, physiological consideration; third, pathological consideration, and fourth, surgical consideration.

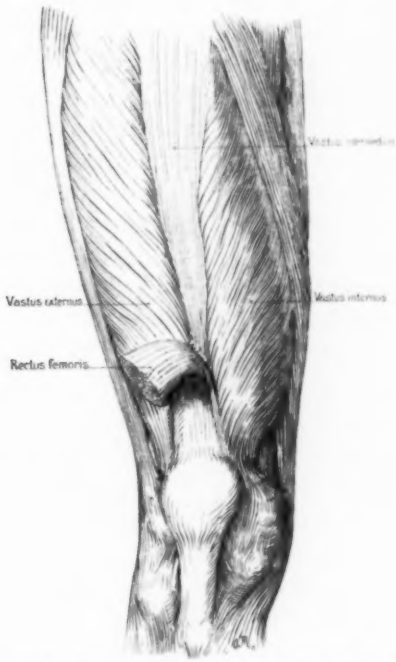
ANATOMICAL CONSIDERATION.

A most concise description of the elements forming the quadriceps tendon we find in Sobotta-McMurrich textbook from which we quote. A very significant fact to be noted is that the vastus intermedius is closely associated with the lower third of the femur, and that the tendinous sections of the same are inseparably united with the vastus lateralis (externus) and the vastus medialis (internus), making it possible by adhesions of the vastus intermedius to prevent the function of the vastus lateralis and vastus medialis.

"The quadriceps femoris consists of four different heads, the most independent of which, the rectus femoris, unites with the remainder only in the lower portion of its course. This head passes over two articulations, while the remaining three are intimately adherent with each other and extend over the knee joint only.

The rectus femoris is a long, thick, decidedly spindle-shaped muscle, which is situated in the anterior femoral region. lying for the most part immediately beneath the deep fascia. It arises by a short, strong, bifurcated tendon, one part of which comes from the anterior inferior spine of the ilium and pursues the same direction as that of the muscle itself, while the other proceeds from the

Sketch No. 1—Showing formation of the quadriceps tendon.



Sketch No. 2.—Rectus detached and retracted.

upper margin of the acetabulum and joins the origin from the anterior inferior spine at a right or obtuse angle, the two together being continued downward as an aponeurosis upon the anterior surface of the muscle. The fibers of the muscle do not run longitudinally, but diverge downward and backward toward the insertion from a tendinous strip in the middle of the muscle. The flat tendon of insertion commences upon the anterior aspect of the muscular belly a few centimeters above the patella and unites with the remaining heads to pass to the upper margin of this bone.

The vastus medialis (internus) is a large, flat, thick muscle situated in the anterior and internal femoral regions. Its origin

is from the inner lip of the linea aspera of the femur, where it is adherent to the insertions of the adductors. Its fibers run downward and forward, some of them being inserted into the upper margin of the patella with the common tendon and some of them passing independently to the inner margin of this bone. The greater portion of the muscle is situated in the lower third of the femur; its outer margin is fused with the vastus intermedius.

The vastus lateralis (externus) is an unusually strong, large, flat muscle, which forms the chief bulk of the musculature of the external femoral region. It is stronger than the medialis and does not extend as far downward as this muscle, being situated chiefly in the upper and middle thirds of the thigh. It arises from the outer lip of the linea aspera as far upward as the greater trochanter and to a certain extent from the outer portion of the latter prominence, and its fibers run quite obliquely from behind forward and from above downward, the direction of the upper fasciculi approaching the vertical.

The entire external surface of the muscle is covered by a broad aponeurosis; its inner margin conceals the greater portion of the vastus intermedius, with which it is inseparably connected, and it is inserted by means of the common tendon into the upper and outer margins of the patella.

The vastus intermedius (crureus) is a flat muscle, the anterior surface of which is tendinous and distinctly excavated to accommodate the overlying rectus femoris. It is the least independent of all the heads of the quadriceps, since its lateral margins are inseparably connected with the other two vasti. It arises from almost the entire length of the anterior surface of the shaft of the femur, and its fibers pass from behind downward and forward into the anterior tendinous surface of the muscle and subsequently into the common tendon of the quadriceps. The lower fasciculi of the vastus intermedius pass to the joint and are known as the m. articularis genu (subcrureus).

The common tendon of insertion of the four heads of the quadriceps arises immediately above the patella by the union of the tendon of the rectus with those of the vasti. It embraces the entire upper and lateral margins of the patella, the latter structure simply serving as a sesamoid bone for the tendon, which is continued to the tuberosity of the tibia as the patellar ligament. The

actual point of insertion of the quadriceps is consequently this roughened process of the tibia."

The blood and nerve supply is only mentioned to state that they in no way interfere with the field of the proposed operation.

PHYSIOLOGICAL CONSIDERATION.

It is hardly necessary to enumerate the functions of the muscles entering into the guadriceps tendon.

Some very evident facts are known regarding the adaptability of muscles when a portion has been made useless by disease or destruction. We see such instances in the gastrocnemius and soleus, where a portion of these muscles has been completely destroyed, and yet the remaining part will function and produce a useful foot.

Another very evident fact is that muscles will function with good power when the distance between their normal origin and insertion has been lessened. One frequently sees a good, powerful, useful leg with a marked shortening of the femur, resulting from loss of substance, faulty position, etc., from complicated fractures. If a group of muscles will compensate and adjust themselves to this condition, there seems to be no reasonable argument why they will not do the same if the tendinous section is lengthened, making them undergo relatively the same change in order to function that they would undergo if there was a loss of substance of some inches of the bone itself.

Experience in paralytic disease, as in anterior poliomyelitis, has proven that full power of all the muscles of the anterior thigh is not necessary for a well functioning leg, except in performing special feats. Ordinary walking requires only a limited amount of power. One would feel free to state that a loss of one-third of the full power of the quadriceps would not interfere with the ordinary function of the leg.

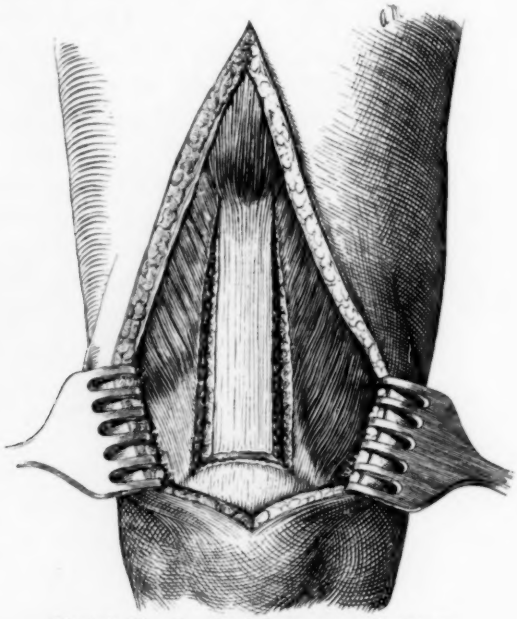
PATHOLOGICAL CONSIDERATION.

Under this caption one must not only consider the actual proven facts that it has been our pleasure to demonstrate, but also the possibilities.

The quadriceps tendon, owing to its location and formation, particularly in its lower and middle thirds, lends itself easily to being fixed to the femur by adhesions, since it has no protective

tendon sheath between it and the bone, and because it is subjected to a great deal of trauma associated with fractures and disease. It might at this point be well to consider an anatomical fact, which is, that the crureus and the vastus internus and the vastus externus are inseparably united in their tendinous formations in the lower third of the femur, so that adhesions of the crureus would result in putting out of commission the greater part of the vastus internus and vastus externus.

Long immobilization with a tendon in complete flexion, will result in the shortening of this muscle and tendon to an extent which in a great many cases results in permanent disability, and resists all other treatment except operative treatment. We see



Sketch No. 3.—Incision separating central section of quadriceps tendon.

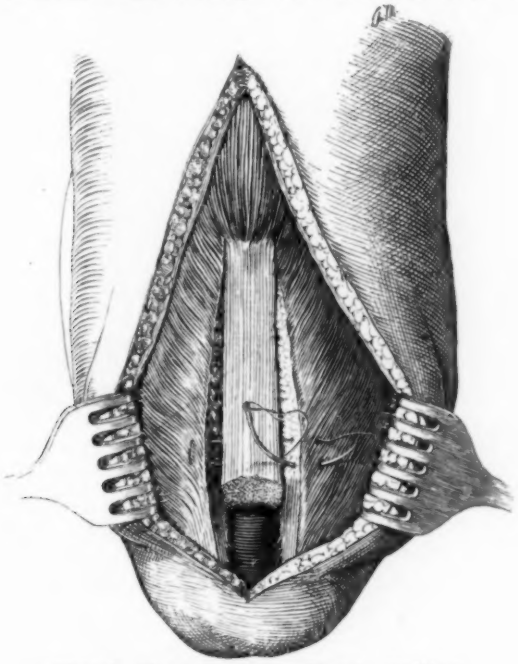
many instances of this in the contraction of the tendo-achilles, where the foot has been maintained in plantar flexion over a long period of time. We see no reason why the same condition would not occur in the quadriceps tendon if the leg is held in its fully extended position for a long time.

To sum up the pathological conditions:—One would have the actual tendon contraction due to long fixation in extended position,

plus adhesions between the muscles and the osseous structures. In one instance we have even seen adhesions between the muscles themselves, which resulted in a painful resistant scar, which prevented full use of the leg.

Surgical Consideration.

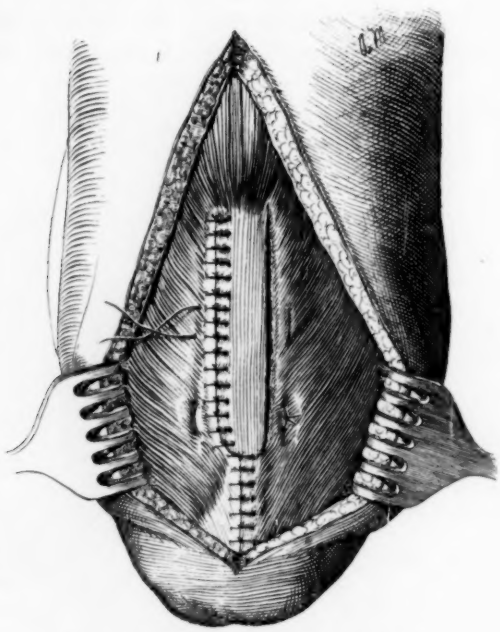
As has been stated before, one very frequently sees complete or partial flexion of the knee joints from conditions already mentioned, in which the joint itself is perfectly normal, and where the lesion has not been near enough to the capsule to cause any par-



Sketch No. 4.—Knee flexed, pulling patella free from portion dissected.

ticular change in the same. The question arises:—what are the structures that are causing this loss of motion? It must be some lesion of the anterior thigh, which results in a fixing of the muscles that control the extension and flexion of the knee. We often see individuals who have ten or fifteen degrees of flexion with good power of extension, all of this motion being accomplished by sections of muscles which are not involved by adhesions. When the

leg is forced beyond this point of flexion, one meets with a sudden shock and one can feel the quadriceps extensor tendon drawn taut. If we analyse carefully the facts associated, knowing that muscles will accommodate themselves to very unusual mechanical obstacles, we see no reason why an attempt should not be made to explore the anterior thigh and to lengthen the quadriceps tendon, feeling certain that the muscles will accommodate themselves to this condition.

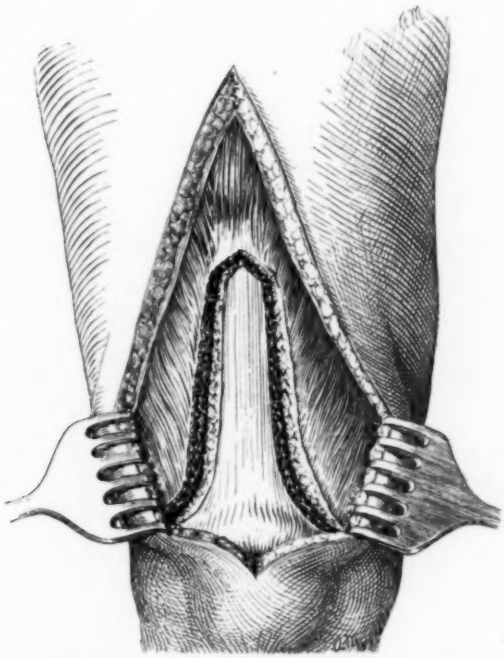


Sketch No. 5.—Method of suturing.

This operation (undertaken by the writer) has been accomplished in two ways. The method used in the operation depends upon determining which particular section of the muscle is adherent. In the first case reported in this article, it was principally the fibers of the rectus which were causing the complete loss of motion, and in this case we separated the middle two-thirds of the quadriceps tendon from the patella, as shown in sketch No. III, then forcibly flexed the knee, and re-attached it at a higher level, stitching together the vastus internus and vastus externus, and fixed the retracted central fibers of the quadriceps to the new tendon made by the vastus internus and vastus externus, as shown in

sketches Nos. IV and V. We, however, feel that this particular type of case does not often exist.

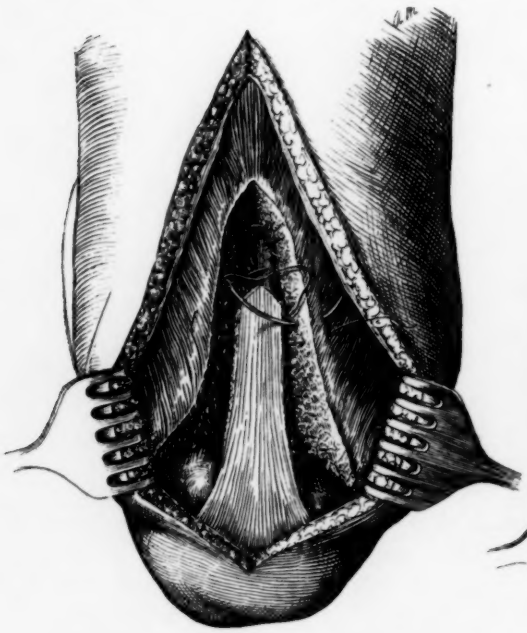
After having examined a number of patients who show loss of flexion as the result of fractures of the lower third of the thigh, which requires plating or long immobilization because of slow union, we feel that it is then that actual shortening and adhesions between the deep central fibers of the quadriceps (particularly the crureus, vastus internus and vastus externus) take place, and limit the flexion of the knee joint beyond a few degrees of motion.



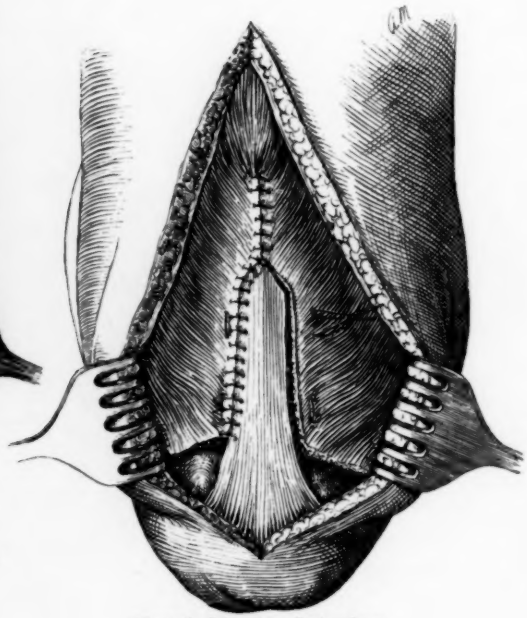
Sketch No. 6.—Incision detaching central section of quadriceps.

Operation shown in sketches Nos. VI, VII and VIII shows the method of handling the same. It consists in severing the central section of the tendon at the point of adhesions, splitting the vastus internus and vastus externus free, and separating the attachment of these muscles from the patella, leaving the central section with a broad attachment to the patella, forcibly flexing the knee, and pulling down the section dissected, as shown in sketch No. VII. The next step is the sewing up of the structures in such a way as to

give the greatest amount of strength. The vastus internus and vastus externus should be firmly united to the patellar tendon, the sections immediately above should be sewed together with either strong silk, kangaroo tendon or chromicized cat-gut, the leg then fixed in a flexion position of about eighty degrees for a period of three weeks. At the end of this time the plaster is removed, and the leg allowed to be fully extended, giving passive motion each second day. This is suggested as a means of making sure that we



Sketch No. 7.—Flexing knee, pulling dissected portion downward.



Sketch No. 8.—Suturing.

have overcome all contractions, and to allow the leg to subside from the acute trauma of operation before fully extending the same. Emphasis should be put upon the fact that motions are passive, and that no effort to use the quadriceps should be made until at least four weeks have elapsed. Massage and stretching as indicated.

REPORT OF CASES.

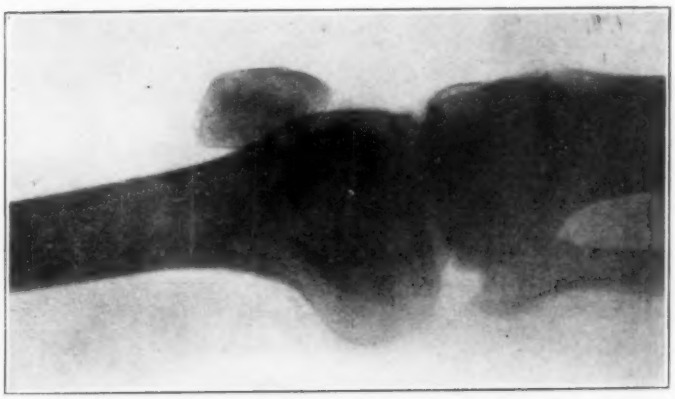
Case No. 1. N. C. Age 34.

Admitted to Johns Hopkins Hospital January 19, 1917.

Complaint—Stiff knee.

Family History—Father and mother, two brothers and two sisters living and well. No history of tuberculosis, heart, kidney or malignant diseases.

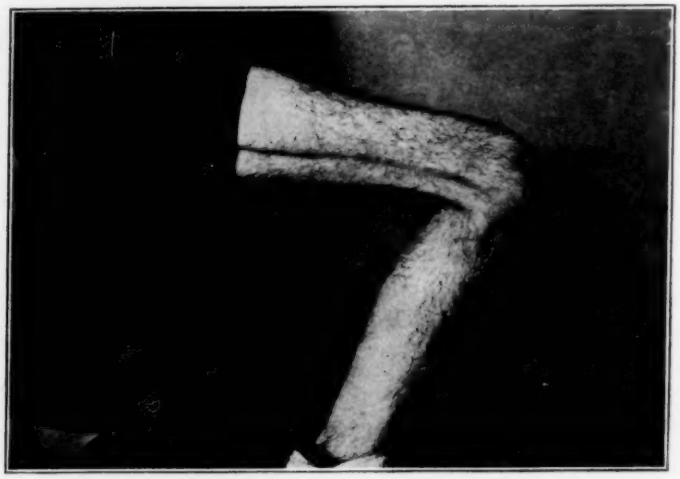
Past History—Has had measles, whooping cough, chicken pox and mumps. Has had several severe colds. The rest of the past history is negative.



X Ray of knee before operation.

Present Illness—Onset after injury to back at the age of 6 or 7. Following the injury the patient was unable to sleep at night for about one month. Then the right leg became swollen and there was marked pain in it. Patient was confined to bed six or seven weeks. After this he walked on crutches. In the meantime abscesses had formed and broken down. Relief from pain after the abscesses broke was marked. Abscesses continued to form at the rate of about two each year. At the age of ten an abscess appeared on the left clavicle, that was treated surgically, and one on the right arm. Several pieces of bone have come from the thigh abscesses at different times. At the age of *fifteen* the right knee became stiff and has remained so ever since. Since twenty-one he has had no more

Photograph before operation



Photograph functioning leg, taken April 1, 1919.

abscesses. Comes into the hospital to see if motion can be obtained in the knee.

Physical Examination—Patient is a well developed and fairly well nourished white man. The examination is essentially negative except for a scar over the left clavicle and the right arm and for the condition of the right leg. There is marked atrophy of the right thigh and there are scars of old abscesses on the outer aspect of the right thigh. The right knee is stiff. Hip movements are normal.

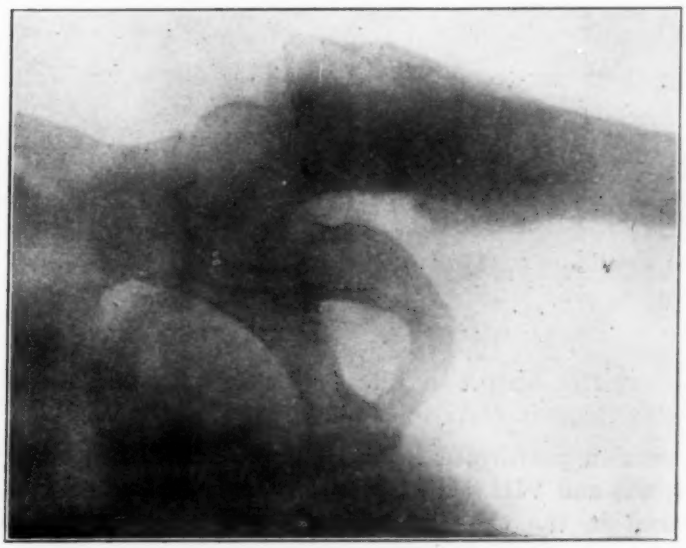
Impression—Osteomyelitis of the right femur with adhesions of the thigh muscles.

Operation—January 27, 1919. Lengthening of the quadriceps, as shown in sketches Nos. III, IV and V.

Patient has a well functioning leg, as shown in photographs taken April 1, 1919.

Memo—Illustrations—

X-Ray of hip
X-Ray of knee before operation.
Photographs of operation.
Photographs taken April 1, 1919.



X-Ray—Osteomyelitis upper third femur, which tied down the fibres of the rectus.

CASE No. II.

Mrs. M. B.

Comminuted fracture of right patella. August 17, 1919.—Open operation and wiring. Immobilization in extension. Massage begun October 20, 1917.

Manipulated under anaesthesia and continued treatment until operation February 4, 1918, at which time patient had 35° of motion, as shown in X-Ray taken with leg held in forced flexion.

X-Ray before operation.

Ten weeks after operation 125° of motion obtained, as shown in X-Ray taken in forced flexion.

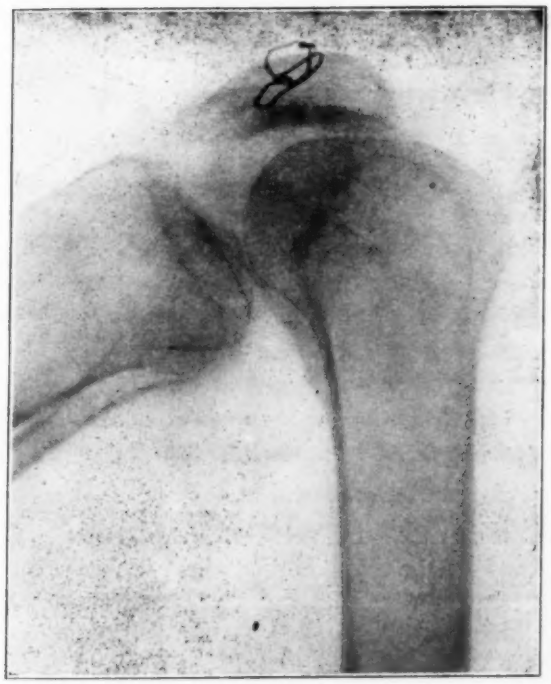
The operation performed in this case is shown in sketches Nos. VI, VII and VIII. We believe that this type of case should be placed in the class of true contractions of the quadriceps tendon.

Memorandum of the illustrations—

X-Ray taken before operation

X-Ray taken 10 weeks after operation.

Photographs four months after operation.



X-Ray ten weeks after operation.

Photograph four months after operation

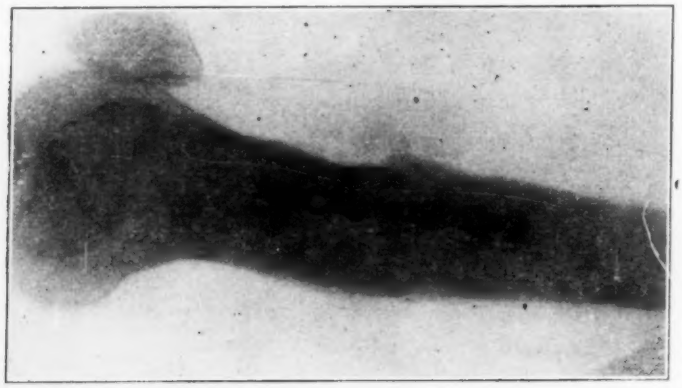
CASE No. III.

G. J. G. Aged 23. White Male.

Admitted to Johns Hopkins Hospital March 12, 1919. Discharged April 29, 1919.

Family History—Father died of heart trouble. Otherwise negative.

Past History—Usual childhood diseases. Frequent colds in head. Otherwise negative.



X-Ray of fractured femur with plating, before operation.

Present Illness—In an automobile accident June 25, 1915, patient sustained a compound fracture of the right femur, eight inches above the knee, and a simple fracture of the left femur, six inches above the knee. Both limbs were put up in traction and the wound on the right thigh irrigated daily. At the end of three weeks an open reduction of the fracture on the left was done, the fragments being plated and the limb being put up in a long plaster hip spica. The wound on the right closed at the end of nine weeks, at which time a plating operation was done on this side too, and a long spica applied. The cast on the left side was cut an inch or so shorter at various times, so that it was not until October of that year that the knee joint was exposed. By the end of December the right knee was also freed for motion, and massage, and later manipulation were instituted. However, legs remained stiff at knees. In August, 1918, several manipulations under anaesthesia were unsuccessful. On September 12th the bone plate of the right was removed without improvement. Stiff knee condition remains as on admission.

Physical Examination—Essentially negative with the exception of the extremities.

Patient walks with knees stiff. There is marked atrophy of the thighs. Left knee joint permits about 15° of flexion, when motion is stopped by a taut quadriceps tendon, apparently tacked down to femur several inches above the knee joint. Knee joint itself is apparently negative. On the right side there are about 10°

Before Operation.

of hyperextension at knee with ability to straighten limb. Here too knee seems to be negative, the restricting factor being a taut quadriceps tendon.

X-Ray examinations on March 13, 1919, showed knee negative for bone or joint changes.

Operation—March 13, 1919. Lengthening quadriceps tendon.

Under ether anaesthesia the patient was operated on for lengthening of the quadriceps femoris. All the tissues at a level of four inches above patella were found adherent and attached to femur below. The anterior part of the quadriceps tendon was cut

free at its superior and lateral margins and by forcible flexion at knee, pulled down. The tendon was sewed in place in its new position and the gap left by its being slid down, was covered by the tissues lateral to the space. Tissues above were then closed and a plaster cast applied from groin to ankle, with limb flexed at 80°. Patient left the table in good condition.

The post operative course of the whole was uneventful. Some ecchymosis appeared about the thigh. The temperature went up to as high as 101 on several occasions the first week. After that, however, condition was excellent. On the 27th of March the cast

Photograph six weeks after operation

was removed. The wound was found healed per primam. The knee could be flexed to 100° without any discomfort. Following this a mild course of massage and later manipulation, was begun.

At time of discharge patient was able to actively extend his knee to within 15° of normal. Limb could be flexed to 80°. There was practically no local discomfort.

This patient at date of writing (April 20th, 1919) is walking about the wards without support with a good functioning leg.

Memorandum of illustrations—

X-Ray before operation.

Photograph before operation.

Photograph six weeks after operation.

A SELF-CORRECTING BRACE FOR LATERAL CURVATURE OF THE SPINE.

BY DR. WALTER TRUSLOW, BROOKLYN.

Presented at the American Orthopedic Association, 1919.

This frame consists of two parts, a lower fixed segment and a laterally-moving segment. The fixed half embraces the pelvis and lower trunk to the level of the vertebra which marks the change from the lower to the higher spinal deviation. It is thus made like the lower portion of a Knight spinal brace, with the addition of a mid cross-bar. The lower half carries the two corset flaps. The upper segment is a parallelogram of brace steels, so attached to the upper end of the fixed half that it may move laterally and only in the direction of correction of the badly carried upper trunk. The lower ends of its four uprights are so hinged to the mid cross-bar of the fixed segment as to allow motion in the lateral plane only; a set-screw acts as stop to prevent motion in the direction which would increase deformity. To the upper corners of the movable half are attached shoulder straps, as in the Knight spinal brace. The parallelogram arrangement of the uprights and compensatory hinges, at the upper ends, insure maintenance of support of the "low shoulder"—it affords lateral carriage of the upper trunk, not lateral bending. To give also direct corrective pulls on the two spinal deviations, hand-like pads on the two side prominences, with arm-like horizontal rods, are carried from the uprights; and traction is made when these uprights move laterally. A downward projection of one of the lateral uprights insures this pressure on the lower spinal deviation, on the principle of leverage of the first order; the attachment of the upper traction arm to the middle upright, above the latter's fulcrum on the mid cross-bar, gives pull on the upper spinal deviation, on the principle of leverage of the second order. Attention is again called to the set-screw, which not only stops the lateral motion in the faulty direction but which by adjustment causes the correcting lateral motion to be as great or as little as is desired.

In the treatment of lateral curvature of the spine, this brace has its place between the use of rapidly correcting plaster of Paris

jackets and of intensive muscle training. It should be ready for use as soon as the last corrective jacket is discarded; the rapidly corrective exercises are started at the same time. Practically it may be used while considerable deformity still exists. With a six to eight per cent deviation and rotations not greater than ten degrees, it is a useful adjunct to the further correction which proper exercise will insure. Its constantly self-correcting and correction-holding elements, together with extensibility to meet growth, make it useful much longer than any brace which has not these features.

TREATMENT OF UNUNITED FRACTURES

F. C. KIDNER, F. A. C. S., MAJ. M. C., DETROIT.

The terms ununited fracture and non-union are purely relative ones, and are much too commonly used. As a matter of fact non-union of fractures is extremely rare if proper mechanical treatment is used. Broken bones have an extraordinarily persistant tendency to unite if given a chance. Non-union frequently is the invention of the surgeon, who is not content to give nature time or who does not know the proper use of splints. Although all fractures are ununited from the moment the injury occurs until complete solidification is established, the term ununited fracture should not be used until periods of time much longer than most of us care to wait have elapsed. The process of new bone formation in fractures is dependent on so many factors of which our knowledge is incomplete, that we should train ourselves to wait and watch without interfering with nature's handiwork.

Delayed union is the result of many causes, not the least of which is meddlesome surgery. For this reason so called non-union in simple fractures is more common in civil practice than in war time. In civil life the surgeon has time to watch the daily progress of the fracture, and to change the treatment constantly. He tries to hasten union, because his patient is in a hurry. In war the surgeon is greatly overworked and he is forced mercifully to neglect his fracture cases, and to be content if his apparatus is holding. In war the patient has unlimited leisure, and can be kept in bed. Thus it happens that in war fractures physiological, and continuous rest is more commonly the fortunate lot of the fractured bone. We all know that irresistible temptation to change the splints, in the hope of getting a little better position, which often overwhelms us to the ultimate detriment of the case. In army hospitals we avoid this temptation in the happy knowledge that our extensions are holding.

Delayed union may be caused by systemic changes such as malnutrition or syphilis. Such causes must be recognized and removed. If they are not removed they may cause ultimate non-union. Delayed union may be caused by extremely faulty position, but rarely non-union. In the army we marvelled daily at the tremendous obstacles in the way of bad position bones overcame and united firmly. Delayed union may be caused by sepsis, but septic

fractures with very few exceptions do unite. It may very rarely be caused by the intervention of muscle and fascia between the fragments. If this occurs ultimate non-union usually results. This cause is more common in civil life than in war because the majority of war fractures are open ones and are explored at the time they are received.

In war surgery delayed union and non-union were most frequently caused by considerable loss of bone substance, incurred at the time of the injury or through excessive zeal on the part of the surgeon who explored the fracture. The most serious, difficult and frequent problems of the orthopaedic surgeon were the cases of greater or less loss of substance in the continuity of the shafts of long bones. Those that were caused by enemy missiles were less difficult than those caused by the enthusiastic surgeon who had done a thorough "debridement." Debridement in conservative and skillful hands saved many limbs and lives, but debridement which ruthlessly removed loose bone in the hope of getting asepsis was an unmixed evil. Better far the controllable sepsis from infected bone fragments than the aching void of the aseptic radical cleansing of the compound fracture. Even very septic and apparently devitalized bone fragments had an uncanny knack of coming to life and acting as bone grafts. When they were aseptically removed only the troublesome and always doubtful bone transplant could repair the damage.

Most cases of ununited fractures then are not true examples of non-union, but are really only delayed union, and are to be treated conservatively as such for very considerable periods of time. Conservatism with proper mechanical aids in skilled hands will in a large majority of cases save time over surgical operations, which aim to hasten union. This is true of ordinary civil life fractures, but is especially true of war fractures. In war fractures, because of recurrent sepsis following bone surgery, is an ever present menace. No set period of time elapsed after healing of the wound insures against this menace. Three months, six months, a year, give increasing safety, but I have seen pus pockets in the deep tissues at operations on fractures eighteen months after complete [illegible] of the wound. And these operations have been followed by a streptococcus infection rivalling in severity the original sepsis. Operative interference then in delayed union is to be discouraged, except as a last resort.

Certain factors in the prevention of non-union are of the utmost importance. First and most important of these is the immediate alignment of the fragments by efficient traction, applied in the direction of the axis which muscle pull gives to the shorter or less easily controlled fragment. The heaviest traction applied to a fracture of the upper third of the femur, while the leg is abducted and extended, will not give good alignment of the fragments, nor will it do so if applied to a fracture of the lower third if the knee is straight. The traction must be in the line which the shorter fragment naturally takes; in the first example abduction and flexion, in the second with the knee flexed to a greater or less degree. It is impossible to pull a fracture of the upper third of the radius into alignment with the hand pronated. Immediate reduction, that is, within the first hour or two, is of great importance for two reasons. First, because less traction is needed to obtain alignment before irritative tonic spasm is set up in the muscles. Second, because the early blood effusion from the bone fragments contains many osteoblastic elements. If reduction is obtained before this effusion has stopped and coagulated, then the bone forming elements are better distributed and arranged to form a plastic callus and bring about prompt union. Good alignment once obtained by traction must be maintained constantly, and for a considerable period of time.

Early alignment by traction is most important in all fractures, but hardly second to it in importance in badly comminuted fractures is the retention in place of all possible bone fragments. Too much stress cannot be laid on this. No fragment of bone should be removed unless its presence so seriously blocks the depths of the wound, that safe drainage cannot be established. The removal of bone fragments to obtain aseptic closure, or to avoid drainage is not justified. Most bone fragments which have any attachment to soft tissue will in spite of sepsis live and produce new bone. Bone fragments which are wholly free will often acquire new attachments, and act as grafts.

If delayed union occurs it is most commonly from neglect to obtain and hold good alignment, or because of considerable loss of substance, but the other factors, systemic disease, sepsis or muscle intervention, occasionally are causative agents. Of these three, medical examination and treatment will remove the first, and efficient drainage the second. The third is only recognized with

difficulty. It should be suspected where examination shows excellent alignment, but where union does not take place in spite of long continued rest, and when no other cause can be found. It can be removed only by operation.

To overcome bad position, and obtain good alignment, when union has been delayed for some time, requires much skill and judgment. It can usually be done, however, by appropriate mechanical means. For example, the accurate application of a pair of calipers or tongs with traction to the lower end of a femur which has been long displaced backward, will often pull it up into place and, by bringing fresh bone surfaces in contact, produce union. In the application of the calipers the greatest care must be taken to apply them at the exact anteror posterior position to obtain the best leverage. In the upper end of the humerus extreme abduction with strong traction may rotate the shaft on the neck in such a way as to give good apposition, and ultimate union. Or again, in the humerous simple extreme abduction by taking off the pull of gravity, may allow the fragments to come into close contact and bring about union. This last fact is most important, as many humeri fail to unite because the weight of the lower arm and forearm acting constantly over long periods of time actually pulls the fragments out of contact.

To overcome delayed union caused by loss of substance is frequently impossible by purely mechanical means. In small gaps up to one or one and a half inches it is sometimes justifiable to remove traction and encourage shortening in order to get the bone ends in contact. This is particularly true of the humerous and forearm. Excellent useful results may be obtained in this way. If the gap is too long to permit this procedure, then maintenance of good alignment and the exercise of inexhaustible patience will sometimes achieve a result. Nature will do much in the way of autogenous grafting. Several times I have been chagrined as I waited for the disappearance of sepsis before doing a bone transplant, to watch by means of the X-ray a delicate line of new bone gradually bridging the gap. This may start from the ends, the fragments, or from periosteum left scattered along the gap. Such autogenous spontaneous grafting may obviate the necessity for surgical interference.

The more one sees of this tendency of bone to bridge gaps in its continuity, the more one is surprised at the extraordinary vi-

tality exhibited by the smallest fragments of bone and islands of periosteum. Early examination of fractures from which large amounts of bone had been removed by the original injury or by surgical interference often gives the impression that there can be no vital bone forming elements between the ends of the main fragments. The small pieces of bone or shredded periosteum look too badly infected or de-vitalized ever to take up any osteogentic function. Yet the X-ray will reveal during the later weeks or months islands of new bone which can have no other origin than these despised fragments. One is forced by such experiences to the belief that bone instead of being one of the least resistant structures to infection and trauma is really one of the most resistant. Part of a fragment may die and come away as a sequestrum, but part of it is pretty sure to live and grow.

Massage and other similar measures to maintain and stimulate the nutrition of the soft parts in the region of a slowly uniting fracture are of undoubted value in promoting union. Manipulation or other systematic means of irritating the fragments are usually harmful. They only serve to increase fibrous tissue formation. It is then most important if we are to forestall non-union to do two things, first to obtain early accurate alignment, and to maintain it continuously for long periods and second, to preserve all possible fragments of bone and periosteum.

When all external mechanical devices to overcome delayed union have been exhausted along with the patience of all parties concerned, there do remain a certain number of true ununited fractures. These must be treated by open surgery. The choice of various operations is open to us. Metallic, ivory, boiled bone plates, pegs, tubes, and screws, wire, magnesia, heterogenous and homogenous and autogenous bone grafts and simple joinery of the refreshed ends have all had their advocates and popularity. From them it is our duty to choose only those which the experience of large numbers of careful honest surgeons, working and observing over long periods of time, has shown to be consistently successful. In making our choice we must be guided by many considerations. We must remember the difference between the ordinary run of civilian fractures, and the fractures of battle with their treacherous sepsis. We must realize that the healthy tissues of the civilian will stand much more surgical insult than will the torn, bruised, septic tissues of the soldier.

It is undoubtedly true that many fractures in civil life do unite in spite of the insult of the metallic bone plate, but they do so only because there is enough excess growing power to overcome the atrophy the plates cause. This is rarely true in war fractures. This fact was very prettily exemplified by the experience of two American bone plate artists, who had never had a failure, with whom I had the pleasure of working while orthopaedic consultant in England. These men insisted that certain fractures under their charge could not be held in good position by any known apparatus, and that plating alone could bring about union. At last I reluctantly consented and they did a series of twenty or more cases in spite of G. O. No..... Careful investigation later revealed that over sixty percent of these cases were complete failures either because of active sepsis stirred up or because the bones would not grow. Bone plates do unquestionably cause bone atrophy. The X-ray will prove this. This atrophy is often limited to the immediate neighborhood of the plate, the rest of the bone growing well and uniting. The femur is the only bone which has enough size to allow this double process of atrophy and growth to go on in a really satisfactory manner. There is no question that bone plates increase the risk of sepsis. When applied to actively septic fractures, as they were by a number of surgeons in 1916, 1917 and 1918 they are positively dangerous. A questionnaire sent out in the summer of 1918 to 35 or 40 prominent English, French, Italian and American surgeons revealed the fact that only one was still using the bone plate in freshly infected fractures. In the old septic fractures of soldiers it is rare that the metallic plate can be made to stay clean and hold. Wiring is open to the same objections that metal plates are. It causes atrophy by pressure, inhibits bone growth and is prone to infection. It has the added disadvantage of instability. Metallic bands have the same inherent weaknesses. With boiled bone or ivory plates, screws and pegs I have had little experience, but believe that they act as irritants and fregn bodies and will therefore be inefficient in a large percentage of cases.

What then are the best operative procedures? They are those whose keynote is the most absolute simplicity. They are those which do the least possible trauma to soft tissues and to the bone itself. The easiest, simplest operations done in the easiest and simplest way are the best. In fractures where there is little loss of bone substance an operation which removes scar tissue and

freshens enough of the ends of the fragment so that fair sized areas of bleeding bone surface can be brought in contact will, if the after treatment is efficient, usually suffice. A cat gut or other absorbable loop thrown round the ends of the bones often helps to steady them. After such an operation the mechanical care is as important as it was after the original injury. Sometimes in order to get good bone surfaces in contact it is necessary to shorten the fragments and to make in them some form of simple interlocking joint. This I find can be done in most cases more satisfactorily with mallet and chisel than with the motor instruments.

Where bone substance is gone, the bone transplant becomes necessary. In the large bones femur or tibia where bone nutrition is good, any type or graft of transplant is usually successful. In small bones or in large ones which are much crushed and eburnized, the type of graft must be very carefully selected. In the radius and ulna nutrition of the ends of the fragments for two or three inches is usually very poor. In such bones if we do a graft which necessitates grooving or drilling or insult to the medullary cavity, failure is a too frequent occurrence. In such cases apparent union takes place within two to three months, but all too frequently at the end of that time, the union begins to weaken and gradually the fracture again become a loose one. The explanaion of this fact seems to be that the grooving of the already damaged bone, still further interferes with its blood supply, and although some fresh bone forming elements are thrown out to make a weak union, they are not enough to bring about real solidification. The best operation to avoid this difficulty is, I feel sure, that suggested by Chutro about a year ago. It consists simply in cleaning one side of the bone fragments and inserting a wafer of perioste and superficial cortex removed from the tibia, between the bone and the periosterm. This is held in its place with cortex to cortex and periosteum to periosteum by simple cat gut stitches. This method interferes with bone nutrition in the least possible degree. It employs a thin transplant in which circulation is easily re-established. It will succeed in spite of considerable sepsis.

Surgery then in ununited fractures should aim first to establish simple contacts between refreshened ends. If this is impossible then in large bones whose nutrition is good use the strong graft in a groove in the cortex, but drill and cut as little as possible. In

the small bones or where nutrition is poor use the thin wafer overlay of Chutro.

All of these operations are subject to failure because of septic flare ups, no matter how long we wait. For this reason I am convinced the two stage method of operating should be used in all cases where there has been sepsis. At this first operation remove scar tissue and explore the field thoroughly. Close up tight. If no sepsis appears in ten days reopen the wound and do the bone operation. If sepsis does appear drain widely and freely and no harm is done. This two stage method will save many disappointments in operating or ununited fractures.

In conclusion:

1. Avoid delayed union by early accurate reduction.
2. Wait for very long periods before interfering surgically.
3. When surgery does become necessary do the simplest possible operation by the two stage method.

DISCUSSION.

DR. H. WINNETT ORR of Lincoln, Nebraska, said that one point to be emphasized was that non-union would no doubt have occurred with much less frequency if treatment had included perfect immobilization and perfect position from the beginning; but, in seeing these fractures at any stage, the first thing was to try and secure immobilization, even after the opportunity for union might seem to have gone by. In the treatment of fractures following injury the question arose as to whether it was better to attempt to restore extremely traumatized parts to normal position, or to allow the inflammation to subside. Sir Robert Jones was emphatic in insisting upon securing return of parts as soon as possible to normal position. If this was not done, patients presented extraordinary difficulties later on. The problem then was whether to establish drainage first, or secure normal position, or both together. At Savenay all that was done was to try to secure position and immobilization and send the patients back to the States as fully protected as possible. One point was clearly shown, that it was necessary to abandon many of the procedures and kinds of apparatus in vogue. This principle should be carried into civil practice. By simplifying methods, young men without any previous experience in fracture, could be taught to be experts in handling of these injuries. Their success showed that very fine work could be accomplished by men who had but a few weeks training. Another point was important, and that was to maintain the full length of the femur even when a large portion of the bone was missing. In the long trying interval before operation, proper maintenance proved of great advantage. One point in regard to fractures of the humerus should be noted: With the long Thomas splint, there was often too much traction resulting in excessive length, and revision of the extremity had to be made by shortening up the upper arm one or two inches. Traction had gone on too long. The standard of work in the A. E. F. was raised by Colonel Goldthwaite's campaign. These methods should be carried into the instruction of students, and to the profession at large. In regard to apparatus: a committee should be appointed to revise text-books in regard to methods of splinting. Anyone who now consults text-books is left in a haze ,and very likely to choose an unsatisfactory method. If students could be taught a simple, practical group of methods

of splinting, that could be applied to all fractures, under all circumstances, orthopedic teachers would have accomplished one of the most useful results to be obtained from our war experience.

DR. DEFOREST P. WILLARD said that he was with Major Kidner during the first part of the overseas work. They were brought up on the same military surgical principles. He could heartily endorse the statements made in regard to treatment of ununited fractures. He believed that nature could do more for the bone than the doctor could. Until nature proved she could do nothing more, the doctor should stay out. Operative procedures should be avoided until absolutely necessary. The best help was afforded by proper fixation and immobilization. Cases had been sent home on account of sepsis, to wait for operation, and had come back later with absolutely solid union. One man who had lost two inches of bone in the tibia was sent home for 6 months, and came back with an absolutely solid autogenous graft of his own.

Another important point was the pre-operative care of these cases. Given a non union case which would need bone grafting, it must have the most careful pre-operative treatment, to insure the best ultimate function of the limb. Non-union was only one of the things that was wrong with that limb. Especially in the lower arm cases, there was great destruction of muscle tissue and loss of function: stiff fingers and wrists, and loss of elbow and shoulder motion, loss of pronation and supination. These should be most carefully treated. If one waited till after the insertion of the bone graft, one had lost the most valuable time for getting back motion and correcting deformity. All cases should have the benefit of early hydrotherapy, massage, and active and passive exercise. Tendon transplantation could be done early and the bone graft later. In loss of radius or ulna, the hand would tend to deviate to the side of the injury. That could be avoided by treating early by means of a short plaster splint with cuff across the hand, short enough not to interfere with massage of the fingers. The support should go half way up the arm.

In regard to the interval between time of healing of the war wounds and time of operation, some men advocated going in very early. In England, however, they did not operate for a year, but that would seem a little too long. Still, it was better to be on the safe side. The best method after a severe infection with streptococcus or gas bacillus, was the two-stage operation 6 months after injury. Then scar tissue should be excised and the ends of the bone cleaned up, taking cultures at the time of operation. With negative cultures it was safe to go in a few days after healing of the soft parts. The second operation was much easier and the chance of sepsis was decreased. In regard to the type of graft, small bones needed a small graft. Mechanical fixation of the radius or ulna by the graft was not necessary. The Chutro graft with an excess of periosteum, to aid blood supply, gave the best results. Cases had been seen in England and France where the large graft put into ulna or radius had held for three or four months and then absorbed, and the men came back with as bad a fracture as they had at the beginning. There was no doubt that no case should be considered as being one of non-union until nature had been given every chance; that where non-union was assured, the 2-stage operation gave the best results; that the autogenous bone graft gave the best chance of attaining solid union.

DR. Z. B. ADAMS of Boston said that he thought the chief points had been emphasized. but there were one or two which it might be well to mention again, the first of which was that time was most important to give nature a chance. Things could be done to stimulate union of bone. Jones drew attention to the fact that hammering the site of the fracture at intervals of a week would stimulate union by causing local hyperemia. In regard to metal plates, everyone was agreed that treatment by metal plates was not the best way to treat delayed union. It might do a good deal of harm. In one case seen of plating in the arm bone, the man had a perfectly satisfactory arm for several years, at the end of seven years it was found that he had a slow low-grade osteomyelitis, caused by the plate. A standardized method of treatment was best in which the bones were

brought into line and held there, and function of the surrounding joints and nutrition of the muscles and soft parts was maintained. Such procedures would tend to limit the number of delayed non-unions.

MR. HEY GROVES of Bristol, England, who spoke by invitation, said that he had been introduced as delegate of the British Medical Association, to the American Medical Association. This was incorrect, he was delegate from the Royal College of Surgeons, and he felt so proud of the fact, that he wanted it mentioned. He was the youngest member, and probably selected because of the fact that his mind was still young enough to receive stimulation. He wished to speak on a great many points in this interesting question, and hoped that courtesy to a guest would not prevent the Association stopping him when he overstepped the time limits. Mr. Hey Groves said that he had been associated with Major Kidner at Shepherd's Bush Hospital, and he cordially agreed with him in some points, and as cordially protested against others. There were some important points in regard to the treatment of comminuted fractures that could not be passed over. Dr. Kidner's general remarks on this question were correct, that was, fragments should be left in position, but there was a difference in the interpretation of results. In fracture removal of the fragments was often undertaken as a primary step. The speaker said he was rather skeptical about the osteogenetic power of the periosteum. If comminuted fragments were immediately removed there was no trace found of young bone formation. If fragments were left in position for a certain length of time, three to four weeks, and then removed, there was seen a rather thin type of new bone which would have to be restored. If the fragments were left in for 6 to 8 weeks then there was formation of external callus or involucrum. Comminuted fragments were full of bone cells which were poured out upon the vascular portions of the periosteum. But in case of sepsis, the little bits of bone shown in Dr. Kidner's pictures, would never have the chance to do anything at all. In regard to fractures of the humerus and the femur. The two ends of the bone were always sclerosed and avascular, very often full of latent sepsis. The two stage operation was essential here. In operating the scar tissue was cleared off, and the two ends of bone cut off. These latter often gave a pure culture of B. coli or streptococci. It was well to cut off the bone ends very generously, because it was not more difficult to fill a gap of two inches than one inch. It was necessary to get cut raw sufaces of bone in contact by making a block or mortise cutting. The speaker said he was going to shock his audience. It was not enough to introduce raw surface of bone to raw surface and then leave it. It must be tied. In America metal was reserved to make dollars with. In some respects this was wrong. It was of the utmost value to put through bolts and screws of bone, ivory, metal or wire. Mr. Hey Grove said he felt he had got his audience against him, and that was a very stimulating feeling. In regard to the employment of plaster of Paris, it was undesirable after operation to put a limb in plaster of Paris and leave it for many months, but sometimes it had to be done and muscle function had to be restored later. The speaker said he felt the same thing about metallic suture. The less metal used the better, but when one had a fractured femur what was the sense of using a piece of kangaroo's tail to secure the fragments. One had either to leave it with a prayer, or use plaster. The catch phrase "metallic fixation means atrophy" had been overdone. One could only follow it up to a certain point. The point was this: a certain amount of absorption or atrophy did take place at the nuts, but that was only a preliminary stage of repair in normal fractures, and repair never began without osteoporosis before final osteosclerosis took place and formation of a tube. Absorption of calcium salts was not necessarily an evil. A well fitted bone might be securely lifted and kept in place by metallic suture or bone nail or screw. In the case of the femur one could take a very fine drill and make 8 or 10 drill holes in the axis of the bone until every one began to bleed. In this way one could tap the vascular and cellular resources of the bone, which would help in union. In regard to bone graft, Mr. Groves did not believe that one could prevent deformity by use of a plaster of Paris cast. The most one

could do was to minimize it. There was never a case in which deformity was frankly corrected, or over-corrected. In arm injuries, when there was a gap in the lower end of the radius and one had got to put in a bone graft, one could not put it in the position of the deformity; that would simply consolidate the deformity. One must restore the continuity of the bone at the same time that one corrected the deformity. It was well to cut off the solid ends of the bone quite generously to make sure of having thoroughly vital bone, the gap was measured and a little bit more allowed, then a piece was cut from the anterior crest of the tibia, about ¾ inch wide and ½ inch thick, amply provided with periosteum. He did not speak disrespectfully of the periosteum; it was a first-rate thing if one did not expect too much of it. The right use of it made all the difference between success and failure. The fascial covering of the tibialis anticus was taken, because it was a vascular membrane which readily made vascular and organic communication with the vascular ends of the bone. The periosteum had been drawn back from the ends of the bone, the grafts were tapered at the ends and one could then separate the ends of the radius and they would spring in when the graft was in place. The intermedullary fixation assumed a slightly curved line which gave it a bucket handle hold, necessary for pronation. It was permissible to split the fragment of the bed into which one was driving the big end of the graft, and then tie with wire sutures. The periosteum was then sewn over so that the graft was not naked but covered with a petticoat. The little niche formed was a bed for the young bone growth to take place. That graft was mechanically perfect and could not shift in a day or a month. One man was so pleased with his arm as the result of this operation that he climbed a wall and broke it again. Another man went and got married and had such a splendid honeymoon that he broke his arm again. It was well to put on a moulded splint which could be laced on, to afford protection, and by this method one was independent of very long plaster of Paris immobilization.

Dr. E. W. Ryerson of Chicago, Ill., said that his sympathy was with the officer who got married and broke his arm. He had noted a little inconsistency in the bone bridging method described by one of the speakers, who said he had cut away bone and brought the ends together without shortening! That was magic. He was interested in Dr. Kidner's methods of grafting, but some of these were still sub judice; one method would not work under all circumstances. The sub-medullary method of Mr. Groves was very useful, yet all knew how difficult it was to divide synostoses and get good results afterwards. Stiles had devised a good method for loss of pronation and supination, in ankylosis of the elbow. He removed a section of the ulna above the pronator quadratus, thus causing a non-union. A man without pronation and supination was in a hard position. One could make a false joint, but the arm would not be as strong as before, and not very good in hard labor, such as farming. If one did not wish to carry out the two stage operation, one could test the limb by active massage and physio-therapy beforehand; if there was no reaction, and if the scar was losing its red color, one could perform the operation at one sitting. Even if there were symptoms of infection, one could not keep the soldiers sitting in a hospital a year longer. It would be pretty hard for medical men to stay in the service long enough to do these late operations, but that was a question to be settled by the wise fathers in Washington. On the other hand, there was the two stage operation. It was difficult to persuade the soldier to submit to two operations in rapid succession, but most of them would stand for anything provided there was hope of success. More light was needed in cases of non-union of the femur with wide separation of the bones. He thought it was possible to put in Chutro grafts, although that was not as good as the intermedullary or inlaid graft, but could be put in earlier than two later.

Dr. John Ridlon of Chicago, said that there were two points to be considered in the question of bone grafts and plating bones. Grafts were put in to fill in a space and plates to fix the fractures while the bones were in contact. The bone graft for filling in space met the problem, but there was no necessity of bone

grafts for fixing fractures, which could be more readily fixed by metal plates. Metallic fixation of broken bones might hold them in a pus cavity in some instances until union took place. It was doubtful if bone inlays would unite in the presence of any considerable quantity of pus. Fractures could be fastened by metal attachments and even if suppuration occurred, union would take place and the metal could then be removed. One point did not seem to be fully clear in the minds of the speakers, and that was the reason for atrophy in these bones. The metal plate had been credited with all the bone atrophy. The bone atrophy which resulted in delayed union or non-union was due more to disuse than to any other factor.

Dr. Albert Freiberg of Cincinnati, said that there were a number of points, which, in spite of study were not very clearly understood. Foreign bodies, such as plates, frequently operated as a cause of non-union. Before the war many men had had the experience of seeing fractures fail to unite until removal of such plates. After removal of plates and subsequent fixation by splints, the fracture united. The relationship of infection to non-union was not yet perfectly understood. In his work at the Walter Reed Hospital, the speaker said he several times found non-union present in the presence of sequestra. These bits of bone were left in presumably because they had periosteal attachments and were supposed to act as osteogenetic centers. It was necessary only to remove these fragments and subsequent union took place. It was not advisable to perform a plastic operation too soon. Union could be given an ample opportunity to take place first.

Dr. Kidner said he fully agreed with Dr. Freiberg that metal plates were often a distinct cause of non-union, whether by chemical or mechanical action. Dr. Freiberg mentioned sequestra: that was a difficult problem to determine what were sequestra and what were viable bone fragments. When the X-ray showed small areas of dense bone lying in line with the fracture, of the type ordinarily considered sequestra, it would often be found that these fragments had some blood supply and took an active part in healing the fracture. Dr. Porter's remarks about the splitting operation were theoretically true, but in a great many cases after splitting, further atrophy went on and the graft lay loose in a completely atrophied lower fragment. A graft laid in contact with small lower fragments was much more likely to do good.

Dr. R. T. Taylor of Baltimore, said that there were two fundamental factors that could be agreed about: those were the question of alignment and circulation. If either were interfered with there would be failure and non-union. Scar tissue or muscle tissue causing mal-alignment, must be removed, and if it is necessary to secure alignment temporarily by some device, one had to use it. In recent cases seen of gun-shot wounds of the patella, which had been sutured and repaired, but by absorbable or metallic sutures, patients had made a misstep and the sutures had pulled out and fragments separated. A method was devised by Dr. Taylor, which approximated the fragments by chromic cat-gut or kangaroo tendon, putting in double mattress sutures on each side. An X was formed at the patella, by taking a strip from the tibia, cutting it in two, crossing it and mortising it together and inlaying, so that in future any strain would pull the two V's together and tighten them in their bed. A diagram of the inlay X was shown afterwards, also X-Rays of cases before and after bone grafting.

Dr. John L. Porter of Chicago, said that it was difficult to fix a bone graft into small atrophic fragments, as in the case of the radius with loss of substance. A perfect end of the lower fragment of the radius could be tapered off, but on account of the traction of the pronator quadriceps the end of the bone was tipped. He had found a method of attaching a bone graft to these small fragments, without sacrificing bone. The small fragment was split, and a piece taken from the tibia was chiselled and driven into the fragment, using this as a lever and dropping it in, in correct position. Thus one had a bone graft with sharply pointed end, which would allow of pulling the small fragment up into position.

DR. TORRANCE RUGH of Philadelphia, said that the condition of sepsis had been considered the greatest factor in the present war, and all attention had been focussed on that. The individual factor had been lost sight of. Internal secretion has a most profound influence on bone proliferation. Many of these cases of delayed or non-union would be benefitted by treatment with thyroid or any of those glands which influence metabolism.

Mr. Hey Groves said he would like to add a word about bone plating. He had uttered a plea for the occasional use of metallic fixation. In the Lancet in 1914 he had stated that "the bone plate had led to the death of the patient or the sacrifice of the limb." He had made this aggressive statement to draw attention to this fact. If the American surgeons in 1918-19 had been content to learn by the work of the British, they would not have had to learn by bitter experience. The speaker said his cases showed 4.5 per cent. of cases of non-union in fractures. The shortening operation was applicable to the humerus. In the femur one could get one and a half inches compensation by tilting the pelvis, and one and a half inches by wearing a proper boot, therefore one should try to bring ends together if possible. In regard to the influence of the periosteum, that was a vexed question. The influence of MacEwen's work was admitted, but these views had been fully borne out by experiences of the war.

DR. FREDERICK C. KIDNER said that he had listened to Mr. Hey Groves with pleasure. He was a brilliant refutation of the idea that the mind of the English surgeon moved in ruts. His work also seemed to contradict the idea that the Englishman was patient and the American in a hurry. It would seem that the American workers were content to wait longer than were the British. It was true that there were fractures where metal plates, or similar attachments did help enormously, but almost all the metal junk put in had to come out later, and often it did interfere with bone proliferation and union. The question of length of bone had been mentioned. He had not enlarged upon that as it was a doubtful subject. It seemed that if fractures could only be brought into good contact by shortening, and if shortening did not interfere too seriously with function, then it should be done. In the humerus, radius, and ulna and some times in the femur, it might help in getting a useful result. Mention had been made of joint function; every fracture that it was possible to treat by fixation with simultaneous motion and manipulation of adjacent joints, should be so treated. Certain types of apparatus permitted motion with fixation, but fixation of the fracture must be secured at all costs. Periosteum was a very useful structure, it acted as a matrix which supplied nutrition. In the vast majority of cases it also carried a certain number of bone producing cells from the superficial layers of the cortex, which had true osteogenetic power. Dr. Ryerson spoke of the type of graft. It made comparatively little difference in the large bones which type were used, if properly placed, but in the small bones, any graft requiring much manipulation would interfere with nutrition of the damaged bone and delay union, rather than hasten it. The value of the Chutro graft lay in the fact that it did not interfere with the blood supply of badly damaged bone.

THE PEDAL GROUPS

BY WILLIAM JACKSON MERRILL, A.B., M.D., CAPTAIN M.C., U.S.A.,
PHILADELPHIA, PA.

Any divergent notion concerning the mechanics of the foot structures, as to the existence of arches in the true sense, challenges the views and theories of orthopædists and other members of the medical profession who have based their opinions upon various hypotheses defended by exponents of certain postulates formulated from an incomplete comprehension of statics and posture.

The majority of persons to whom the duty comes to analyze the altered conditions of posture of the foot structures, think first of the arches as the starting point of the trouble, especially if they have had but a limited experience in the treatment of the foot affections, and the first thought is to prescribe a prop for the arches. It would be better for mankind if the notion of arches had never been born.

The type of foot that shows an inward deviation at the ankle joint seems to be a serious problem to many, and it is all the more confusing to such persons when this condition is called "ankle valgus." Pronation means precisely an inward deviation at the ankle joint which permits of a rotation of the foot inward on its longitudinal axis. Valgus, according to the old conception of the term, denotes a combination of deviations. Why add mystifying terms to a foot that has simply tipped inward? If these conditions, also flaccid flat foot and other variations in the posture of foot structures, due to combined mechanical and physical defects, were analyzed from the point of view of anatomy and physiology, and the process of thought were from deep within the patient's constitution outward, rather than from without inward, to just below the skin, falling flat at the "arches," the problems would cease to be puzzling.

When one loses time considering whether the "anterior transverse arch" (the existence of which is purely imaginary) has "fallen" and experiments with methods of propping up this chimerical structure, as a rule he succeeds in making the trouble worse if, in the beginning, it were a little more than trivial.

The action of the foot in performing its functions in the process of walking consists of two phases: one period for the time the

heel is on the ground and the other from the time the heel leaves the ground until the thrust of the toes is completed. The behavior of the different structures in the two phases varies considerably. It is the purpose here to call attention to these variations rather than to discuss the mechanics and nature of the defects.

The greatest strain in the foot, whether its structures be in the normal or abnormal state, is during the act of walking, and not in standing. It is during the period in which the heel is off the ground, in the act of walking, that the true arch principal does not exist. As soon as the heel is raised from the ground, the mechanical principle embodied in the combined structures of the foot, change from the arch to the suspension principle. The percentage of strain at any given point is greatly increased by the discursion of a given part from its normal relationship with its reciprocating structures. The ratio of strain to the angle of deviation is indirect rather than direct. The change from the normal relationship of the several segments of the foot under the stress of weight bearing and other functions, varies widely in accordance with the relative superimposed weight, the muscle state, the mode of use of the feet, and the type of foot gear.

Analyzing the mechanical construction of the lateral pedal group, composed of the os calcis, cuboid, fourth and fifth metatarsal bones and their phalanges, and the fascia, tendons, and ligaments that support them, we find the following facts: the pull of the tendo-achillis on the os calcis tends to force the latter upward and backward and to cause it to rotate upward and backward on its transverse axis. These movements are prevented by the plantar ligaments, plantar fascia and to a lesser degree by the pressure of the ligaments on the sustentaculumtali. The pull transmitted through the os calcis to the plantar fascia and ligaments is applied to the distal ends of the metatarsal bones. These structures acting according to the bow-string principle with the bones of the foot form an arch. The lateral pedal group in most feet does not constitute an arch in the concentric sense, because these bones are in a practically straight line and the force of the ventral ligaments is not sufficient to maintain the principles of an arch in these bones. The points of weight bearing when the heel is on the ground (first phase) being the tuberosity of the os calcis, the tuberosity of the fifth metatarsal bone and the distal heads of the fourth and fifth metatarsal bones, for the lateral pedal group, make these structures

weight-bearing, more than stabilizing, elements, but when the heel is raised from the ground the structures of the lateral pedal group enter into the mechanism of the foot as suspension and stabilizing fundaments more than weight-bearing structures. Arches can only be considered as such, purely in the mechanics of weight-bearing in the foot, when the heel is on the ground. It is under this condition that the outer pedal group is a weight-bearing structure in the pressure stress sense. This pressure stress in the lateral pedal group is changed to a tensil stress, chiefly in the os calcis, when the heel is raised from the ground, and the only remaining concentric arch is practically the mesial pedal group. The forces which are applied to the astragalus to force it upward and forward in walking, arise in the tendo-archillis and the posterior muscles of plantar flexion of the foot.

When the heel is raised the superimposed weight of the body is transmitted through the tibia and fibula, astragalus, scaphoid, and the three cuneiform bones to the three inner metatarsal bones and the latter bear chiefly the weight of the body. The mesial pedal group is supported posteriorly by the suspended os calcis when the heel is raised in walking and anteriorly on the distal heads of the three inner metatarsal bones. There is a slight movement antero-posteriorly of the astragalus on the os calcis and this factor tends to make less stable the longitudinal arch of the foot when the heel is on the ground in weight-bearing.

In pronation, flattening, and valgus, and combinations of these conditions, the os calcis is moved outward and the axis of the pull of the tendo-achillis, instead of being in line with the tibia, is at an angle, and the stress thus applied forces the astragalus inward. Under these conditions the strain and disability vary indirectly with the deviation of the os calcis outward and with the stress.

During the process of walking, the heel is on the ground only about one-fourth or one-fifth of the period in which the foot is in the act of assisting in executing the stride, and the true concentric arch principle exists only for that period. As soon as the heel is raised from the ground, the structures of the outer pedal group of the foot are supports, mechanically, according to the suspension principle.

In analyzing and treating foot troubles, after the constitutional and local causes have been determined, the chief consideration in a given foot trouble should be applied to the period of time that the

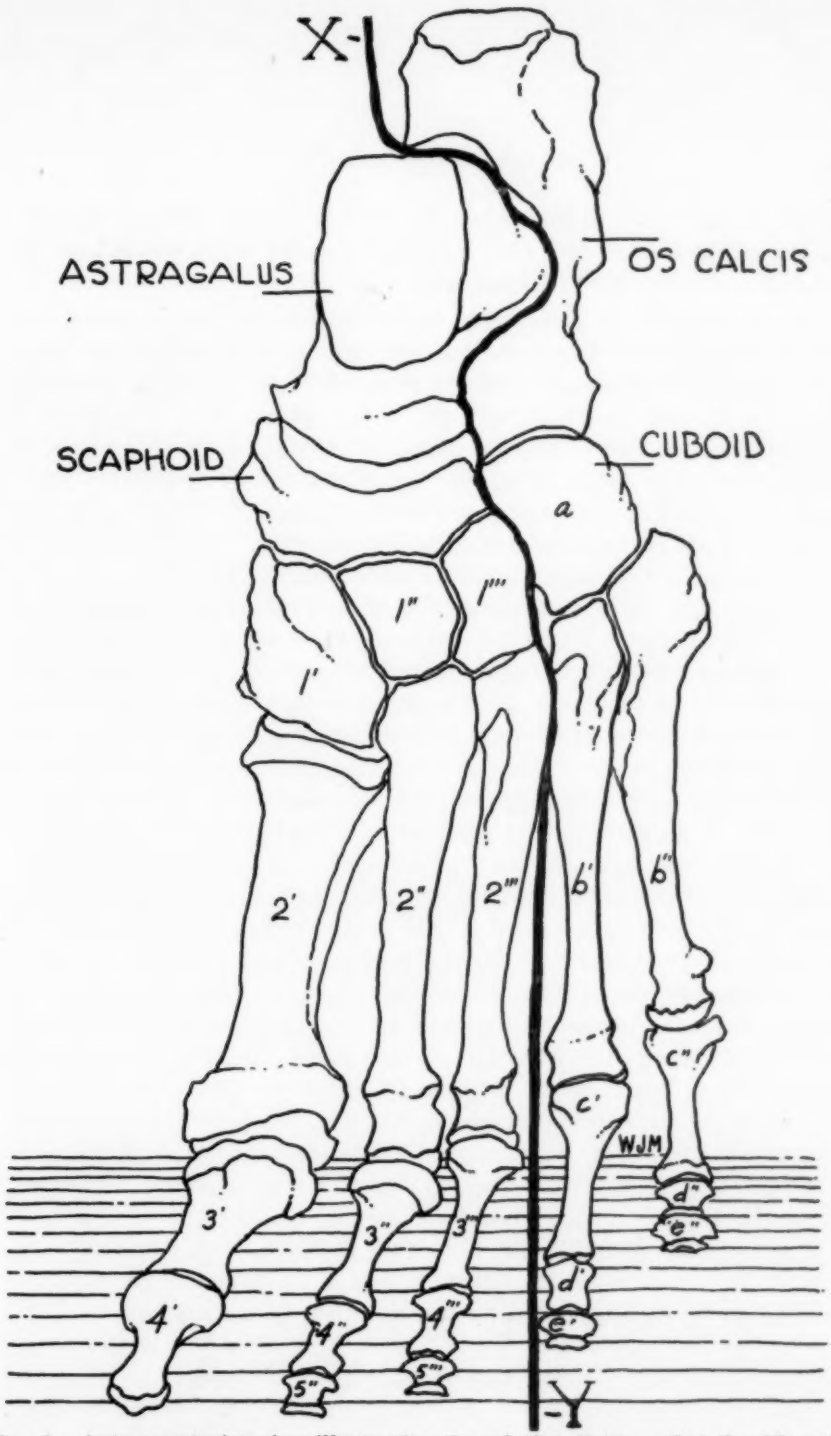


FIG. 1.—Antero-posterior view illustrating the relative distance that the 4th and 5th metatarsal heads are raised from the ground when the heel is raised in the act of walking.

The mesial pedal group consists of: Astragalus, Scaphoid, Cuneiform bones (1', 1'', 1'''), the three inner metatarsal bones and their phalanges (2', 2'', and 2''', and 3', 3'', and 3''', etc.).

The lateral pedal group consists of the Os Calcis, Cuboid, 4th and 5th Metatarsal bones (b' and b''), and their phalanges.

The line x-y denotes the line of *anatomical and mechanical cleavage* between the mesial and lateral pedal group.

weight of the body is borne by the foot when the heel is raised, and the behaviour of the foot structures under such conditions of stress and strain should be known.

Anatomically, mechanically and functionally the longitudinal arch is composed of the os calcis, astragalus, scaphoid, cuneiform bones and their metatarsal bones, when the heel is on the ground. Anatomically and mechanically the bones of the feet are divided into two groups, which may be called the Pedal Groups: the mesial includes the astragalus, scaphoid, cuneiform bones and their metatarsal bones and phalanges; the lateral is made up of the os calcis, cuboid, and its metatarsal bones and phalanges. The inner Pedal Group includes the three metatarsal segments, the first, second, and third, each being composed of a cuboid and a metatarsal bone and its phalanges. These metatarsal segments comprise the anterior portion of the longitudinal arch when the heel is raised from the ground, and form the most important part of the longitudinal arch when the heel is on the ground. The outer metatarsal segment, composed of the cuboid, the fourth and fifth metatarsal bones and their phalanges, is a stabilizing structure to a greater extent than it is a weight-bearing structure. When the foot structures and posture are normal, the os calcis and tuberosity of the fifth metatarsal bone are on the ground and bear weight with the distal heads of the five metatarsal bones proportionately as the line of weight bearing stress. When the heel is raised from the ground, the pressure stress of these bony structures is changed to a tensile stress, which is imparted to them through the tendo-achillis, the plantar ligaments, the long and short plantar flexors of the fourth and fifth toes, the plantar fascia, and the peronei tendons. Through the action of these tendons and ligaments, the lateral pedal group becomes a stabilizing structure. These structures, especially the os calcis, act as a lever in supporting the astragalus; moreover, when the heel is raised from the ground the weight of the body is transmitted, through the tibia and fibula, to the astragalus, to the scaphoid, and to the three inner metatarsal segments, the astragalus being supported by the os calcis in accordance with the true suspension principle. Figs 1 and 2. The amount of weight bearing rendered by the fourth and fifth metatarsal bones is produced by the plantar flexor muscles of the fourth and fifth toes and the fascia and ligaments. The chief amount of change from the normal, in flattening and pronation, takes place in the mesial pedal group.

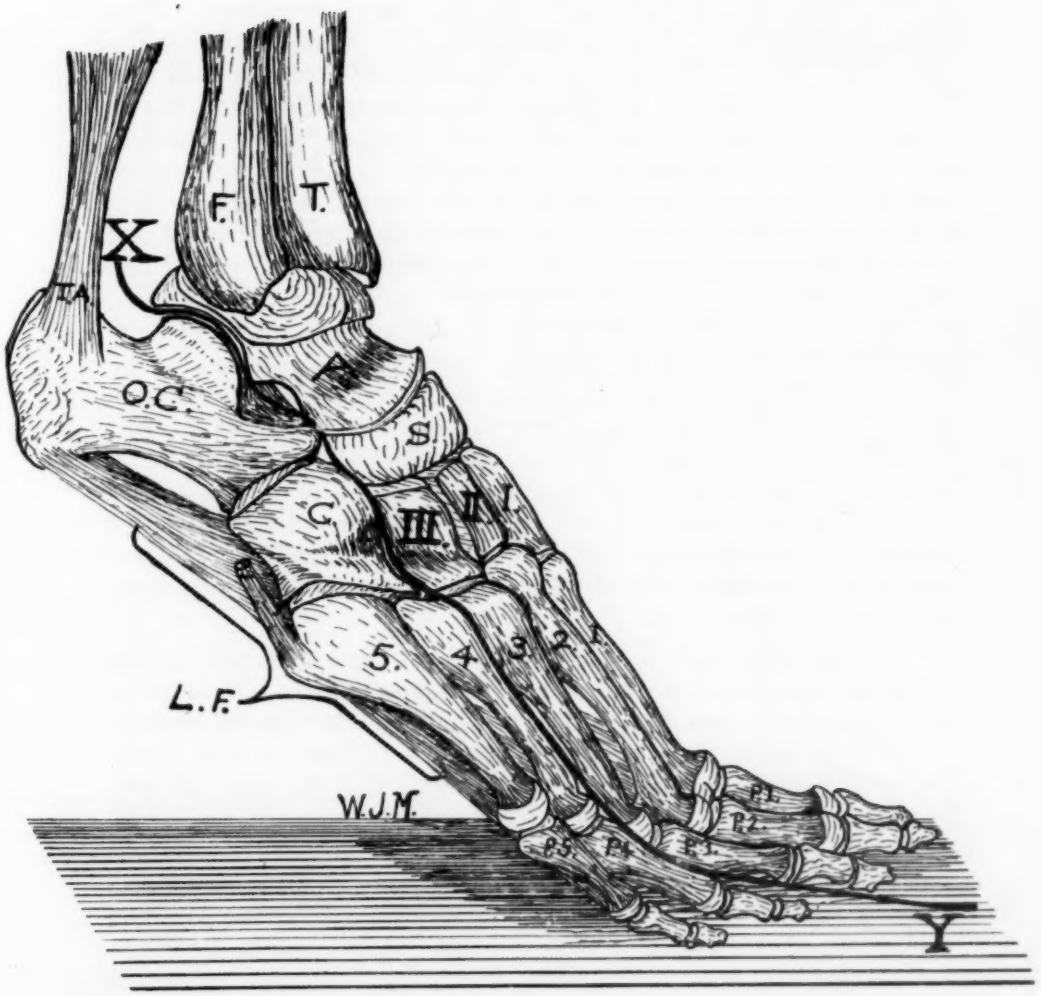


FIG. 2.—Lateral view of heel—raised as in Fig. 1—to illustrate the raising of the 4th and 5th metatarsal heads from the ground when the heel is raised. The line x-y denotes the *anatomical and mechanical cleavage* of the mesial and lateral pedal groups.

The proximal ends of the metatarsal bones move inward and downward when flattening or pronation, or both, takes place. Since the distal heads are fixed on the ground, this movement imparts *torsion strain* to the metatarsal and mid-tarsal structures. This strain produces pain which is usually located in the anterior metatarsal structures. The method of treatment of abnormalities, and the relief of the pain in the tarsal and metatarsal structures due to strain, must be based on these mechanical axioms. It is obvious then that methods of treatment must be applied to the weight-bearing structures in accordance with the mechanics of their discursions from the normal. In flat foot, the os calcis has moved forward and downward on its transverse axis, and inward on its vertical and longitudinal axes. The astragalus moves forward and downward, the anterior breadth of its trochlear surface is greater than the posterior breadth, the inter-malleolar space has a similar cuneiform shape, and this movement consequently increases the lateral play of the astragalus. The scaphoid moves downward and inward with the cuneiform bones and the proximal ends of the metatarsal bones. The downward and inward movement of the os calcis carries the cuboid downward and imparts a downward and inward torsion strain to the latter. By these combined movements, a torsion strain is imparted to all of the foot structures, but especially to the inner pedal group.

The restoration to the normal position of these weight-bearing structures must be accomplished by measures which will re-establish: power and tone to the muscles and ligaments, good posture of the weight bearing structures, correct use of the feet in performing their functions, and supports so applied that the fore foot will be adducted, the midtarsus moved outward and upward, the astragalus and os calcis moved outward and backward and the weight consequently thrown to the outer border of the foot. Supports must be combined with the shoe and stabilized with the sole and heel, or the attempt at correction will fail. It must not be forgotten that the support is only temporary, that constitutional causes must be eradicated, that local measures, such as massage, indicated applications, exercise, etc., must be employed, and that correct use of the feet in walking and standing must be practised.

H. AUGUSTUS WILSON, M. D., F. A. C. S.

DIED APRIL 16, 1919

An appreciation by Dr. R. W. Lovett of Boston. Read at the meeting of The American Orthopedic Association June, 1919.

Augustus Wilson died of uraemia after an illness of three days at his home in Philadelphia, on April 16th, 1919, and by his death orthopedic surgery lost one of its most representative men, and the American Orthopedic Association lost a devoted servant and a faithful friend. Born 65 years ago, he graduated in 1879 from Jefferson College and began medical teaching at once in the Philadelphia College of Anatomy. He taught later in the Philadelphia Polyclinic and in the Women's Medical College, and in 1904, he became clinical lecturer on orthopedic surgery in the Jefferson Medical School, later to become clinical professor, and in 1904 professor of that subject. He resigned his professorship and was made emeritus professor in 1918. A teaching record of some forty years is an exceptional record, and one of importance when that teaching, as in his case, was always sound and sane and painstaking. A great number of students pass through the hands of a man who teaches for forty years, and a widespread influence on the profession is exerted by such inspiring and honest teaching as that of Wilson. In this matter he laid the medical profession and orthopedic surgery under a heavy debt. He was connected first and last with many hospitals of the first class, a catalogue of which is not necessary. To these he rendered the devoted service which was characteristic of all that he did. From the time that he joined this association in 1891, until the time of his death, he was one of its most useful and influential members, and he served it in many capacities, as president, member of the executive committee, member of the publication committee, and in minor places. The association had few more regular attendants, and few men more conscientious in going to all of every session and doing what he could to make each session a success. I should say that the man's chief characteristics were earnestness, unselfishness, kind heartedness, and absolute devotion to a cause once undertaken. He was a man of ideals which he never sacrificed, his profession and his family filled his life, and he had few outside interests. He was a most indomitable worker and he had one agreeable trait, that of making the man with whom he talked think more highly of himself than he did before the conversation, for he seemed to look for the best that was in each man, and to dwell on that side of his relation to each one. I never knew him before we met in the association, but this relation as a co-worker with him in the publication committee led to an intimacy between us which lasted to the time of his death, and this intimacy led me to recognize in the man a rare unselfishness, a real idealism and a sincerity of purpose which may well serve as an example to any and all of us.

GWILYM G. DAVIS, A. M., M. D., L. L. D., M. R. C. S. (ENG.) F. A. C. S.

DIED JUNE 16, 1918.

An appreciation presented at the 1919 meeting of the American Orthopedic Association by J. Torrance Rugh, M. D., Philadelphia.

A short pause in the activities of this energetic society is taken to consider the loss of an Active Fellow who in the twenty-one years contributed thirty-four papers to the Transactions and was repeatedly chosen to fill official positions.

His charming personality, his scientific attainments, and his unselfish devotion to his profession resulted in his being adored by his patients, worshiped by his assistants and endeared him to those with whom he was brought in contact.

Dr. G. G. Davis became a Fellow of the American Orthopedic Association in 1897 and received many tokens of the high esteem in which he was held by the Fellows. At the time of his sudden death, June 16, 1918, he was the newly elected treasurer. He had held the same position from 1907 to 1913, retiring to become president in 1913. He was second vice-president in 1901 and also in 1903.

Dr. Davis was born in Altoona, Pa., July 20, 1857. His father was Thomas Rees Davis and his mother Catherine Fosselman Davis. He was graduated from the Central High School as A. B. in 1876 and five years later A. M. was conferred upon him. In 1879 he graduated in the Medical Department of the University of Pennsylvania and in 1881 he received the degree M. D. in the University of Goettingen, Germany; in 1880 M. R. C. S. (England) and L. L. D. from Lafayette in 1911.

In the early years of his practice of medicine he was largely known as a general surgeon because of his extensive and skillful work as surgeon to the German Hospital and senior surgeon to St. Joseph's Hospital and surgeon to the Episcopal Hospital. As Associate Professor of Applied Anatomy in the University of Pennsylvania he acquired that intimate knowledge of anatomy that made his surgical procedures definite and certain.

His interest in orthopedic surgery was acquired through his connection with the Philadelphia Orthopedic Hospital and became deeper through his Fellowship in the A. O. A. Upon returning from one of the annual meetings of the A. O. A., Dr. Davis determined to resign all hospital positions except those that were entirely orthopedic and devote all his energies to orthopedic surgery. From this time on his contributions to orthopedic literature became more frequent and of greater scientific value. His book on Applied Anatomy, published in 1910, attracted great scientific attention.

His private practice became so large as to necessitate assistance, which he secured by engaging Dr. F. D. Dickson. When Dr. Dickson accepted the call

to go to Kansas City to become Associate Professor of orthopedic surgery in the University of Kansas, Dr. DeForest Willard took his place as Dr. Davis' associate. This continued most happily until Willard entered the U. S. Medical Service.

The winter of 1916-17 was a particularly arduous one as his position on the Advisory Orthopedic Commission to the Surgeon General demanded great additional work in instruction in military orthopedic surgery at the University of Pennsylvania. His undergraduate teaching, his many hospital positions, and his private practice gave him no time for relaxation. He sought the privacy of his camp in Maine but, alas, pneumonia developed and, being far from medical attendance or nursing, he succumbed on June 16, 1918.

Dr. Davis was elected Professor of Orthopedic Surgery in the Medical Department of the University of Pennsylvania 1911. He was Chief Surgeon to the Widener Memorial School. He was a Fellow of the American Orthopedic Association; Fellow of the Philadelphia Academy of Surgery; The Philadelphia College of Physicians; the American Medical Association; The Philadelphia Pediatric Society. He was a member of the Iota Chapter Phi Beta Psi fraternity and also of the Alpha Mu Pi Omega of the Medical fraternity. He was a member of the University Club and the Art Club. Dr. Davis was a bachelor.

His contributions to the American Orthopedic Association were:

1898. The Operative Treatment of Webbed Fingers.
A Brace for Cases of Lateral Curvature of the Spine.
A Brace for Pott's Disease of Spine.
Head Support for High Pott's Disease.

1899. The Technique of Osteotomy, with the Description of a New Osteoclast.
A Brace for the Treatment of Stiffness of the Elbow.
Instruments for the Formation of a New Acetabulum in Congenital Luxation of the Hip.

1900. A Brace for Lateral Curvature of the Spine.
An Operation for Ununited Intracapsular Fracture of the Neck of Femur.
A Splint for the Treatment of Equino-varus.

1901. A Brace for Antero-posterior Curvature of the Spine.
A Flexible Curve and a Flat-foot Plate.

1902. Lateral Deviation of the Spine.
An Apparatus for Paralysis of the Extensors of the Hand and Fingers.

1904. A Forcible Reposition of Congenital Luxation of the Hip.
Club Foot Stretcher.
The Treatment of Lateral Curvature of the Spine.

1905. An Apparatus for Making Passive Motion of the Elbow.
Multiple Cancellous Exostosis.

1907. A Method of Reduction of Congenital Luxation of the Hip by Manipulation.
Resection of the Knee with the Object of Obtaining a Movable Joint.

1908. An Operative Treatment of Intracapsular Fracture of the Neck of the Femur.
A Brace for the Retention of Congenital Luxation of the Hip after Reduction.
A Sling for Head Extension.

1911. An Operation for the Treatment of Anterior Dislocation of the Head of the Radius.
A Rolling Bench for Use After the Reduction of Congenital Luxation of Hips.
The Treatment of Paralytic Outward Rotation of the Foot.

1912. The Structure and Mechanism of the Human Joints in Health, Disease and Injury.
Proceedings of the Fourth Italian Orthopedic Congress.

1913. The Treatment of Hollow Foot (Pes Cavus).

1914. The President's Address: The Education of Crippled Children.

1915. Local Treatment of Painful Nontubercular Joints.

1916. Stability of the Lower Extremity in Paralytics.
Treatment of Paralysis Following Poliomyelitis.

1917. Lumbo-sacral Pains Considered Anatomically.

Current Orthopaedic Literature

OSTEOMYELITIS. By F. H. Baetjer, M. D., Baltimore, Md. Maj. Med. Res. Corps, U. S. A. *The American Journal of Roentgenology.* Vol. VI, (New Series June, 1919. No. 6.

In a normal long bone we have a medullary canal containing the blood supply, nerves, lymph, vessels and marrow fat. Then we have the dense hard bone surrounding this which we call the cortex, this, in turn, being covered by a fibrous sheath, the periosteum; and at each end of the bone we have the joint surface, namely, a cartilaginous covering. Any one or all of these structures may be involved in an inflammatory process. When the periosteum is involved we have a periostitis; when the infection is confined to the cortex we have an osteitis; an infection of the medullary canal is a myelitis. The combination of diseased cortex and medullary canal we speak of as an osteomyelitis.

While the pyogenic factor may vary in bone infection, the process is the same, varying only as to the severity and duration of the infection. In a general way we may speak of four portals of entry:

1. Hematogenous or lymphoid in origin.
2. Infection lodging beneath the periosteum.
3. Arising in the joint.
4. Direct inoculation, as in wounds and compound fractures.

In the first group, the blood or lymph supply carries the infection through the nutrient canal into the medullary portion of the bone; and since this is filled with the soft marrow fat, the infection may spread easily and rapidly up and down the medullary canal.

When the infection lodges beneath the periosteum we have it and the bony cortex involved. Since the cortex is quite dense, the infection is more or less limited and does not tend to spread; consequently in this type the medullary canal is not often involved, but we have an extensive periostitis and osteitis.

When the infection starts in the joint we have an extensive destruction of both articulating surfaces, and finally the disease breaks through one of the cartilaginous surfaces and destroys to a more or less degree the head of the bone, where cancellous bone is present; and here again the infection extends but slowly into the medullary canal proper. In compound fractions the infection is carried directly to the medullary canal and raw exposed bony surfaces so that periosteum, cortex and medullary canal may be involved simultaneously.

The only two changes that take place are bone destruction and bone reproduction. It is the variation in these two processes which determines the diagnosis. Normal bone is pierced by numerous small Haversian canals which are in direct connection with the medullary canal. An infection that starts in the medullary canal not only extends up and down, but also into the Haversian canals. If the infection is virulent there is evidence of bone destruction, confined at first to the Haversian canals, and finally by extending down these canals, the infection will completely surround a portion of bone, thus devitalizing it, with the formation of a sequestrum. If the infection is virulent, this

takes place rapidly and the most marked changes are those of bone destruction with but little new bone formation. New bone formation is a repair process and does not take place until nature is getting the mastery of the infection. In the very early stages of even a virulent bone infection the bone may be perfectly normal in appearance upon the roentgen-ray plate, but at operation one finds the little canals that traverse the bony structure completely filled with pus. No bone destruction has as yet taken place and consequently the roentgen-ray plate will be negative. Such a case examined a few days later will show beginning destruction.

An acute osteomyelitis gives the following picture upon a roentgen-ray plate. The infection, having lodged in the medullary cavity, takes the path of least resistance and extends along the medullary cavity resulting in vacuolated spaces represented by areas of lessened density. The infection now spreads to the bony cortex and travels irregularly by means of little bony canals producing areas of bone destruction with normal bone in between, and eventually these areas of normal bone will become cut off and form sequestra. This is an important point of differential diagnosis, because every pathological process in bone must be viewed as a possible malignancy until proved otherwise. Malignancy in long bones starts from one central point and radiates equally in all directions, absorbing the bone as the growth advances, but never appears as separate areas with normal bone in between. The osteomyelitis infection will finally pierce the cortex in one or more places, leaving areas of normal cortex in between.

With the piercing of the cortex and the acquired resistance of the tissues, nature now attempts to limit the destructive process, and this is done by building up a new bony wall at the edge of the infection. To produce bone reaction there must be a stimulation, and the point of stimulation is always at the point where the infection stops and the normal bone begins. The result of this will be that the new bone laid down will follow the edge of the infection. This gives a varied picture, as the destruction will determine where the new bone will be laid down.

The deposit of periosteal bone will frequently be sufficiently great to give the appearance of expansion of the bone. Close inspection will reveal that the apparent expansion is in reality due to deposition of bone on the outside. This is an important point, as benign growths of the bone, such as cysts and osteochondromata invariably expand the cortex, while osteomyelitis does not.

The predominating feature in acute osteomyelitis is bone destruction with but little new bone production. In chronic osteomyelitis the conditions are exactly reversed. There is excessive bone reproduction with a few small areas of destruction. The entire bone is thickened, frequently to such an extent that the medullary cavity seems to be completely obliterated. The bone is often irregular in shape and thickened, due to extensive deposition of periosteal bone upon the cortex. In the bone there may be small areas due to little focal spots of infection. The following points must always be carefully noted:

1. The place where the infection starts.
2. The character of the destructive process.
3. The path of extension, that is, spreading equally in all directions or following the path of least resistance.

4. The character and situation of new bone production.

5. The condition of the cortex, whether it is intact, destroyed as a whole or pierced by sinuses, expanded or not.

In luetic osteomyelitis the lesions are generally observed in more than one bone and the clinical picture does not coincide with that given by the roentgen-ray. In lues the plate may show an apparently very acute osteomyelitis, evidenced by extensive destruction, the entire bone being involved, yet there will be but few clinical symptoms.—*Leo C. Donnelly, Detroit.*

FRACTURES OF THE FEMUR. A critical analysis of 131 cases of fracture of the femur, treated at the American Red Cross Hospital, No. 2, Paris. By Kenneth Bulkley, M. D. Major, M. C., U. S. A.: formerly chief of surgical service, American Red Cross Military Hospital, No. 2, Paris, France, and Donald B. Sinclair, M. D. Captain, M. C., U. S. A.

It is the object of this paper to analyze statistically 131 consecutive cases of fracture of the femur treated in the American Red Cross Military Hospital No. 2 at Paris.

1. A compound fracture of the femur should be operated upon and held for a month, or immediately transported without operation to a hospital where definite treatment can be carried out. It is an injury of war whose mortality rate is high and whose late results are very often crippling. It is an injury to which a sufficient amount of attention is not paid, possibly because often associated at first with relatively small wounds which to the unpracticed eye do not forbode serious results. But it is from these wounds, no matter how small, that the danger arises. Closed fractures of the femur are not of particular danger. Given an associated local wound of the soft parts, and the prognosis becomes immediately worse. And given a combination of the two with an inexperienced surgeon doing inexperienced surgery and an inexperienced "triage" officer indiscriminately evacuating the cases, and the prognosis becomes distinctly bad. We are of the opinion that these cases should either be operated upon and held at an advanced hospital for at least a month, or else given priority in transportation and immediate evacuation to a hospital in the rear which can be reached in less than 24 hours after injury and in which the patient can be held for at least 4 weeks.

2. The chief danger lies in infection, gas gangrene in the early weeks and streptococcus in the later weeks. Both can be best combated by early, adequate, and radical surgery.

3. Bullet fractures are practically as dangerous as are those by shell fragments. The occasional bullet wound may be observed without operation, the shell wound never.

4. Those fractures splitting into the hip—and knee—joints are infinitely more dangerous than those involving only the intermediate portion of the bone. Those involving the hip should probably always be amputated and then disarticulated. The majority of those involving the knee will need resection or amputation.

5. The primary operative procedure should be radical to the point of ap-

parent brutality. We have never seen too large an incision. We have seen many pitifully inadequate ones.

6. Amputation should be done oftener and earlier. Too many attempts are made with disastrous effects as to life to save worthless limbs.

7. The ideal form of traction is skeletal, and this form of traction is practically without danger. Femoral traction is superior to tibial traction.

8. If more care were paid to operative treatment, less would be heard of the chemical treatment of wounds.—*Leo C. Donnelly, Detroit.*

THE INFLUENCE OF THE WAR UPON THE DEVELOPMENT OF SURGERY, by Jos. A. Blake, M. D., of New York, Director of the American Red Cross Hospital, No. 2, Paris, France. *Ann. of Surg.* Vol. LXIX. May, 1919. No. 5.

There has been little of new in the knowledge we have obtained. There has been a confirmation of principles already known, and the progress that has been achieved has been principally in stabilizing treatment rather than in making discoveries. There has been no development to change the underlying principles of wound treatment as recognized and practiced before the war. This, in view of the enormous amount of material offered by the war, might be deemed an admission of failure; but when we reflect that the processes of repair in all wounds, no matter what their cause, are essentially alike, and that these processes have been studied for years, there is little ground for disappointment.

At the outset of the war military surgeons assumed that the great majority of wounds would result from small arms, i. e., rifle bullets, and that the casualties from high explosives such as shells, bombs and grenades, would be in minority. It was also thought that rifle bullets would produce clean, neat perforations such as might be made by a large knitting needle. There was no conception of the fact that the full-jacketted bullet could so often cause bursting and shattering effects. Consequently the dictum was that there would be few operations and that only small dressings would be needed; with the result that inadequate provision was made. When the avalanche of wounded descended, with lesions of indescribable magnitude, and laceration and mostly containing foreign and infectious material, a demand naturally arose from the overwhelmed surgeons for some means, capable of application by no matter what attendant, to combat the frightful infections which ensued. Thus recourse was had to antiseptics, and the antiseptic area was revived. Our old friends reappeared, phenol, Labarraque's solution, iodoform, the metallic salts and alkaloids, as well as the aromatics of the ancients. Perhaps I should not say reappeared, for they were always with us; rather they became dominant. And because they became dominant I feel justified in saying that the early surgery of the war was characterized by retrogression rather than progression.

The principle that well-nourished tissues can withstand and overcome infection, while, on the other hand, tissues bruised and deprived of their circulation not only cannot destroy bacteria but become actual culture media favoring the development of infection, although perfectly well recognized and understood before the war, was often overlooked and forgotten.

War wounds, particularly those caused by artillery, possess all the conditions which promote infection; the structures are torn and disrupted, masses

of tissue may be detached and the projectiles frequently entrain clothing laden with germs.

The treatment of these wounds may be said to have passed through three stages during the war. The first stage was that of debridement: the wound was laid open, the foreign materials removed and the tissues left to eliminate by natural processes those portions which could not live. In order to prevent and combat the fulminating infections resulting from the favorable conditions for bacterial growth, various antiseptics were used, some of which acted directly against the bacteria while others, by a sort of embalming process, rendered the destroyed tissues unfit for bacterial food. The evolution of the wound was characterized by prolonged elimination and suppuration.

The second stage of treatment was that in which substances, such as the hypochlorites were used to dissolve the destroyed tissues and thereby hasten their elimination. Of these the most commonly used in France was Dakin's solution, which was applied throughout the wound by Carrel's admirable method of intermittent flushing. The essential value of the hypochlorites lies in their solvent properties, which, by getting rid of the pabulum for the bacteria, permit the tissues to sterilize themselves. This treatment finds its chief indication for those wounds to which the complete operative treatment about to be described **cannot be applied.**

The third stage might be said to have actually commenced early in the war, but it can hardly be stated to have become generalized before the spring of 1917. It might well be called the stage of rational treatment, for it was based upon the principles already mentioned, namely, that well-nourished tissues can withstand and eliminate infection. Although this principle was well recognized before 1914, it remained to be proved that it was possible, operating under the unfavorable conditions of war surgery, to systematically convert wounds from hotbeds of infection into simple lesions healing immediately by first intention. It is particularly due to the excellent results obtained and reported by the French surgeons, especially Lemaitre, that this treatment became generalized. It consists in paring (epluchage) the surface of the wound, removing all devitalized tissue and foreign materials and closing it immediately, or if for certain reasons this did not seem practicable, leaving the closure to a later date. This rational treatment has not only been extremely successful, but it has saved an enormous amount of time as well as expensive dressing materials.

Although the war has thrown practically no new light on the ordinary bacteria of suppuration, viz., streptoccocci and straphylococci, much has been learned about the organisms producing gas gangrene. It is interesting to note that the treatment of this terrible disease in the early part of the war was also entirely directed against the infecting organisms, while later it chiefly consisted in removing the conditions favorable to their growth. The bacteria producing gas gangrene all belong to the group known as anaerobes, because they thrive best in the absence of oxygen. A common treatment early in the war was to inject oxygen gas into and about the infected tissues; which did not do more than increase the gaseous distention and thus produce more pressure upon the already anaemic tissues. Another treatment was to make multiple incisions in the subcutaneous tissues in order to let the gas escape. This might haxe done good if the gas had formed in these tissues, but the gas there was in-

nocuous. It was not until Kenneth Taylor, working in the Robert Walton Goelet Research Laboratory (then at the American Ambulance at Neuilly), proved that gas gangrene was essentially a disease of muscle tissue—not of healthy but of devitalized muscle—that the treatment was put on rational basis. It then became simple: early excision of all torn and devitalized muscle prevented the development of the diseases, and, when the symptoms had already appeared, removal in their entirety of the muscles involved usually stopped it.

With reference to tetanus, the prophylactic value of the antitoxin was proved, and its use became mandatory in the armies of all the nations instead of optional as had been the case in some. Until then, hundreds of lives were lost because of this lack of appreciation of its value. A profound study of tetanus was carried on during the war, especially in the British army. It was found that the protection afforded by the antitoxin could not be depended upon to last more than from twelve to fourteen days. Thus the occurrence of what is called "late tetanus" was explained, and at the same time its prophylactic treatment was indicated. Studies of the bacterial flora of chronically suppurating wounds show that the tetanus bacillus persists for a long time, especially in and about the dead bone so commonly present in gunshot fractures. The quiescent germs are apparently innocuous, the system of the individual being protected by the wall of granulation tissue lining the wound. If this living wall be broken down, whether by an operation or by rough handling of a fracture, absorption of toxin at once occurs, and, the protection of the original dose of antitoxin having ceased, tetanus ensues. The remedy is evident. Antitoxin must be readministered before any intervention which might destroy the natural barrier of the granulating wound.

Shock is characterized by a progressive depression of the vital forces as evidenced by weakness of the systemic and cardiac muscles, lowering of bodily temperature and finally, death. Hemorrhage causes similar symptoms, and hastens the development of shock; yet pure surgical shock may exist without hemorrhage. It is largely through the investigations of Cannon during the war that a working hypothesis has been reached which affords a reasonable explanation of the phenomena attending shock and at the same time a basis of its rational treatment. Cannon's hypothesis is, that shock is due to a diminution in the normal alkalinity of the blood caused not only by deficient oxidation, but more than probably by absorption of acid substances produced by the catalysis (i. e., chemical breaking down) of injured muscle tissue. Anything which contributes to deficient oxidation, such as the loss of red corpuscles, (hemorrhage) or the reduction of body heat, increases acidosis and shock. And as shock produces cardiac weakness and lowering of blood-pressure (resulting in sluggish circulation and therefore in deficient oxidation), a vicious circle is quickly established and the victim is doomed unless the chain can be broken. It has been found that if external heat be applied to the body, shock may be prevented or even arrested; but if the normal alkalinity of the blood has already undergone a certain diminution, fresh normal blood must be supplied by transfusion in order to restore the alkalinity and increase the blood-pressure and oxygen carriers. Infusion of alkalines are not altogether satisfactory. By transfusion, the patient, having been temporarily resuscitated, is enabled to withstand the operation necessary to remove the crushed and torn muscle

tissues, which, if allowed to remain, would again bring about the condition of shock and in any case lead to serious infection.

The technic of blood transfusion was so perfected and simplified during the war as to make it far less dangerous, thus extending its use and its value as a therapeutic procedure. One of the chief improvements, and one that might well be adopted for any civil hospital, was the classifying of donors among the personnel, so that blood suitable for any case could be immediately available without having to lose time in finding a donor with blood of the same type as that of the patient.

Much study was given to the effects of the different anaesthetics upon patients suffering from shock. Evidence was obtained by questionnaires sent to all the hospitals, and from discussions in the various meetings held in Paris and elsewhere. The consensus of opinion, which agreed with the laboratory findings, was that all the common general anaesthetics: ether, chloroform, ethyl chloride and nitrous oxide were harmful, but that nitrous oxide with oxygen was by far the least dangerous. Although the harmfulness of general anaesthetics was admitted, their replacement by local or regional anaesthetics, except to a limited extent, was not considered practicable or justifiable, as the use of the latter is not devoid of danger. The superiority of nitrous oxide given with oxygen is undoubtedly due to the latter, for by this means the oxygen of the blood is kept at a high point, thus obviating the danger arising from insufficient oxidation.

During the war, considerable advances were made in the surgery of the regions, particularly the chest. Comparatively little progress was made in abdominal surgery. As regards the nervous system, there were certain improvements in technic and many observations of great value, especially as to the prognosis of certain injuries.

In the surgery of the jaw and face the large amount of material afforded an unprecedented opportunity for the artistic and imaginative surgeon; and some of them developed much skill and ingenuity in overcoming frightful deformities and in bridging dental defects. In this work there were not a few transplants and bone grafts, and future observations as to the permanency and the assumption of new function by these grafts will be of great scientific value.

The surgery of the chest has always possessed a charm for the adventurous surgeon, involving as it does that of the heart and lungs, the most obviously vital organs in the body An operation on these moving structures will never fail to thrill the most indifferent and cold-blooded surgeon. Before the war the high mortality resulting from intervention for conditions which were then considered to be sufficiently serious to justify operative treatment, impressed surgeons with the idea that operations upon the chest were excessivly dangerous. There were an enormous number of chest wounds of all descriptions during the war, with abundant opportunity to observe both their immediate effects and more remote ones, such as those produced by infection. One of the most striking observations was in regard to wounds opening the pleural cavity—the so-called sucking wounds. It was noticed that with such a wound a man got along fairly well for a short time and then rapidly went into shock and died. The reason was a lack of oxidation due to inadequacy of respiration. If the admission of air through the wound were stopped, these cases did as well as

those with non-sucking wounds. It became the rule to close such wounds as soon as possible even if they were only provisionally sewn together and had to be operated on and re-closed later. It was found that if shock could thus be prevented, the patient would subsequently withstand a formal operation in the course of which the wound of the chest wall could be excised and enlarged, the lung withdrawn if necessary, the wound in the latter also excised and sutured, and the chest finally closed. Closure of the chest, if only for a day or two to enable the vital functions to become re-adjusted was found to be imperative. Naturally under these conditions, it was of extreme importance that infection should be prevented, and it was therefore necessary to methodically remove the foreign bodies, torn and devitalized tissues, and, more particularly, fragments of ribs, which were found frequently to provoke infection. It was seen that extensive exposure and handling of the lungs was possible, and our pre-war ideas as to the dangers of thoracic surgery became greatly modified. Much was also learned in regard to treatment of infections of the pleural cavities, including the empyemata caused by pneumonia as well as those due to wounds.

Most surgeons in peace time are not particularly interested in fractures. In the first place, they do not occur in large numbers except in great factory or mining centers, and they do not as a rule appeal to the operating surgeon be cause they occupy beds for long periods and do not require the particular skill he possesses, or imagines he possesses, but a more purely mechanical one. At the outbreak of war there was a regrettable lack of knowledge as to the treatment of fractures. There was no authoritative work or report available on the treatment of war fractures, and what we know now may be fairly said to have been almost entirely acquired during the war. This would be unbelievable were it not for the fact that the war fracture differs greatly from the civil fracture in that it is caused by the direct action of a missile while the civil fracture is usually the result of an indirect bending or torsional force. The war fracture is open to infection, the bone is smashed by the projectile, fragments of bone are often detached and driven through the tissues so that they actually form secondary missiles; foreign bodies, often loaded with infectious material, lie in or are disseminated amongst the fragments; the soft parts are lacerated, even pulpified; in short the conditions are all favorable for the severest types of infection. Consequently the surgeon, in treating a war fracture, not only has to keep the fragments of bone in proper position but has also to contend with the worst forms of infection. In order that we may understand the difficulties he has to meet, let us consider what an infection of a fracture means. In addition to the immediate danger to life from sepsis it causes death, or necrosis of the fragments and ends of bone, the amount of necrosis usually depending upon the extent of interference with their blood supply produced by the injury. These dead pieces and ends prolong infection and hinder the processes of repair and union, and have to be removed by operation. If the operations for their removal are not properly timed, or executed, more bone may die or other complications follow. There is always a tendency on the part of the soft tissues to close too rapidly about the dead bone, confining suppuration and thereby causing abscesses to form which often burrow up or down the limb. In short, the clinical course of an infected war fracture is at first a severe infection immediately endangering life, and afterwards a sequence of flares of

suppuration of greater or less danger. The gravity of these infectious processes can be greatly modified by skill and proper treatment.

At the outbreak of the war immobilization was the cardinal principle in the treatment.

In order that this should be perfect, the rules, as laid down in the textbooks, required that the articulations on each side of the fracture should also be immobilized. Treatment throughout the early part of the war was consecrated to the principle of immobilization. The limbs and if necessary the body, were encased in plaster of Paris, windows being cut or bridges of metal being made so as to afford access to the wounds for dressing purposes. What happened? As infection developed swelling occurred, and the plaster casts had to be removed, split, or cut away. When this was not done soon enough, gangrene and loss of life were not uncommon results. When it was possible to keep the plaster casts on, wasting of the limb from disuse made the cast too large and they no longer fulfilled their purpose. Pressure was exerted in spots, causing sores; and filth accumulated beneath them. In some cases pneumonia developed on account of the fixation of the patient in a recumbent position. And if life and limb were preserved, what result was arrived at after this period of torture? In the best hands, as to union it was fair, although there was generally some shortening; as to function it was, almost without exception, lamentable, the joints were stiffened and the muscles wasted. In fractures of the thigh the results reported by some of the best clincs for the first year of the war show that less than two per cent. were fit to be returned to any kind of duty.

The improvement in treatment has been due to the discarding of the old precepts as to immobilization by fixation and the substitution of entirely different principles. The underlying physiological principle may be said to be that of the preservation of function.

The chief mechanical principle involved is that of traction. If traction be made on a broken limb in the direction of the axis of the proximal fragment of the broken bone when in the position of rest, no harmful angulation at the site of the fracture will occur. By position of rest we mean the position occupied when no forces are acting on the fragment other than those produced by the muscles to it. Very little external force (i. e., acting from without) is sufficient to materially influence this position. If a slight restraining external force be provided, considerable latitude of motion of the joint of which the fragment forms a part may take place without changing the position of the fragment. Traction being applied, the confining force provided by the stretched muscles is usually sufficient to furnish the slight external force necessary to prevent motion, and traction in the proper direction may be expected to permit a considerable latitude of motion in the contiguous joints without changing the relative position of the fragments. Traction overcomes the tendency to overlapping and shortening. With traction applied in the proper direction, the bending motion, i. e., angulation, at the site of fracture which may occur in the early days of the injury, is harmless, and the commencing union rapidly affords the slight restraining force necessary to maintain the relative position of the fragments.

It is obvious that if the direction of traction departs too far from that of the axis of the proximal fragment when in the position of rest, angulation will

result at the fracture. We cannot overcome this danger by fixation unless it be complete and the joints on both sides of the fracture be immobilized; for, if we fix one side only, the danger is increased. If there be freedom of play on both sides so that the parts on one side are able to follow any motion of those on the other, the danger is eliminated. This freedom of play is accomplished by suspension and by removing the point from which traction is made to the farthest distance possible from the site of fracture. The point at which traction is made should be, if possible, on the distal fragment itself, so that traction does not have to be made thru the joint distal to the fracture, thereby immobilizing them.

Although nothing new in regard to the operative treatment of fractures has been discovered, we have gained great experience in determining the best treatment to follow. Internal fixation of compound fractures by screws, plates, bands, or wires has been proved to be bad practice and unnecessary. The tendency at one time was towards the complete excision of all the small fragments in order to prevent infection and the continual suppuration which generally occurs when all the fragments are allowed to remain. Many cases of delayed or total lack of union followed complete excision, and the present practice is a conservative resection of enough bone to remove contamination and to permit drainage, while at the same time maintaining continuity of the fragments.

The last stage the author speaks of in the treatment of fractures is actually the first, and is the splinting for transport from the battlefield. The inadequate methods employed in this work was one of the cruellest features of the early part of the war. It was not uncommon for the wounded to be carried from the field with limbs swinging from the point of fracture, and the jagged fragments tearing and lacerating the tissues. The progress realized later was enormous, and here again was achieved by the use of traction, applied chiefly by means of the Thomas splint. This splint, used by the English orthopaedist, Thomas, over fifty years ago, largely as an ambulatory splint for tuberculous affections of the knee, has, with slight modifications in size and form, been of inestimable service, both for transportation and treatment. With two sizes of this splint nearly all fractures of both upper and lower limbs may be transported and treated with success. It is simple and cheap as far as construction is concerned, but it requires considerable skill in handling. For transport its application is governed by definite and simple rules. It was found that the enlisted men quickly became proficient in the application of this splint and were therefore able to splint the wounded where they fell. The latter were thus removed from the battlefield without suffering, and many were saved who otherwise would have died from additional traumatism and shock.

The principle of conservation of function in the treatment of fractures is well exemplified in the Willems treatment of wounds of joints. This treatment, introduced about the middle of the war by Dr. Willems, of Brussels, aims at the retention of motion of the joints by never losing it. The wounded joint is operated upon as usual, the wound "spluched," and closed entirely or partially according to whether infection is absent or present. The after-treatment, which is the essential part of the system, is chiefly carried out by the patient himself and consists in the use of the joint. He begins to move it immediately on

regaining consciousness after the anaesthetic and soon begins to use it. If a knee or ankle, he walks the day after operation. The results have astonished the surgical world. Joints that would have been doomed to ankylosis by the older methods have been perfectly preserved. Everyone who has employed the system agrees that it is marvellous. Some have complained that it lacks the miraculous power of achieving the impossible. This treatment and the discovery that synovial membranes possess great self-protection against infection, are the two great advances in the surgery of the articulations due to the war.

Of the operations devised during the war, one of the most striking is the kinematic amputation of the Italian surgeon Vanghetti. The object of this operation is to arrange the stump so that the remaining muscles may be used to direct the artificial limb or to vitalize the prosthesis. This is a distinct advance and bids fair, judging from the results obtained, to be a very successful proceedure.

The final stage in the influence of the war upon the development of medicine and surgery, lies chiefly in our own hands and depends upon the perpetuation of the cordial and fruitful relations which have existed during the war between the surgeons and physicians of the different armies. It will indeed be regrettable if the stimulus to progress engendered by the meetings of the Interallied Surgical Conference and the Research Committee of the American Red Cross should be permitted to subside. Now is the time to act when the memory of the events thru which we have passed is fresh in our minds and the friendships formed are still warm.

Military organization will have to be supplanted by some other. Shall we look to the national and international societies and congresses, or shall we turn to our great universities? The latter seems to offer the best means for fostering and perpetuating the spirit of enthusiastic co-operation brought about by the war, for they afford opportunities for continuous collaboration and interchanges of ideas. International meetings should be encouraged, not only because of their scientific value but in order to revivify the cordial personal relations which have been such a redeeming feature of the war.

In the near future it is hoped that America may have the honor and great pleasure of receiving our European brothers in order to be able to make some return for the kind hospitality, and thoughtful helpfulness and sympathetic appreciation we have always received.—*Leo. C. Donnelly, Detroit.*

A New Method of Treatment for Suppurative Arthritis of the Knee-joint. By Maj. J. Everidge, R. A. M. C. T. *The British Journal of Surgery*, Vol. VI, April, 1919, No. 24.

To sum up, the advantages to be derived from treatment by early active mobilization appear to be 5, its effects being:

1. To hasten repair by the preservation of a good blood supply to the tissues of the affected joint.
2. To aid drainage, as Willems has emphasized.
3. To prevent extreme atrophy of the muscles, so that these will be better able to resume function when the articular inflammation is at an end.
4. To establish a process of auto-vaccination.

5. To realize the possibility of a subsequently mobile joint.

On the other hand, experience has shown that the treatment is not advisable in cases with gross injury to the articular bone or essential tendons or ligaments; or where suppuration in the joint has gone on for sixteen days or more.

Bacterial invasion of synovial fluid:

1. In 70 to 80% of the cases of penetrating wounds of the knee-joint, this fluid at the original operation shows that "soiling" has occurred. In most it is not possible to see and recognize organisms in it; only on cultural examination can their presence be determined.

2. Where the "toilet operation" has been successful, these organisms disappear. Subsequent effusion, should it occur, is found to be sterile.

3. Where the "toilet operation" has failed as evidenced by the persistence or recurrence of the clinical signs of inflammation more than four days after operation, bacteriological examination reveals organisms in profusion by both direct and cultured methods.

The Cellular Elements.

1. At the original operation the identification of cells typical of inflammation is generally prevented by the presence of red and white blood-cells resulting from a hæmorrhage into the joint.

2. In the absence of such a hæmorrhage, a preponderance of leucocytes is not pathognomonic of severe septic infection of the joint.

3. A differential leucocyte count affords evidence in determination of infection. An 80% polynuclear count marks roughly the dividing line between good and bad prognosis (Lazarus Barlow).

4. The presence of extracellular organisms and of the phagocytosis, when suppuration has lasted for ten days, point to a severe infection and limitation of powers of resistance. Too much reliance, however, should not be put upon this observation.

The following changes in the nature of the fluid escaping from a joint, during the progress of suppurative arthritis, to a certain extent reflect the clinical evolution of the intra-articular inflammation. Three stages may be recognized:

A. Developing.
   1. (a) Synovial fluid discolored by altered blood; (b) Albuminous fluid like coagulating white of egg.
   2. Sero-purulent fluid.

B. Established Suppuration.
   3. Pus. (a) Thick and creamy in staphylococcal infection; (b) Thinner and less viscid in streptococcal infection.

C. Subsidence.
   4. Pus with semi-solid curds.
   5. Curds floating in a clear fluid.
   6. Synovia, clear and limpid.

The stereotyped vertical parapatellar incisions commonly used for drainage for the knee-joint have the following drawbacks:

1. Wide gaping of the skin owing to the run of the natural lines of cleavage in this situation. The result is wounds taking long to heal and ultimately leaving troublesome cicatrices.

2. Joint openings which tend to close early, since the split muscle and tendinous fibres forming the capsule fall together spontaneously.

3. Interference with the blood supply of the patella, since the main vessels, which pass transversely inward, are divided by these incisions.

4. Troublesome hæmorrhage either at the time of the operation or some hours later. The bleeding vessels shrink away into fibrous tissue when cut, and are difficult to secure.

5. Should amputation subsequently become necessary, the anterior flap is interfered with.

Owing to these drawbacks, I have for some time past been in the habit of using transverse incisions. These remain open satisfactorily and, when active mobilization is employed, appear to drain the joint just as efficiently as the vertical incisions. They are made from the outer and inner borders of the patella, commencing at the junction of the upper and middle thirds of the bone, and continuing for a distance backwards of about an inch and a half. These incisions are far removed from the lateral ligaments, which lie below and behind them. The outer incision partially divides the iliotibial band.

The apparatus for active mobilization comprises: (1) A suitable splint; (2) An overhead counterpoise system.

1. The splint: This is an elaborated back splint with foot-piece, and possesses the following features: (a) It is guttered to fit the shape of the leg (b) It is interrupted, when it lies behind the knee, to give access for inspection and dressing. (c) The metal bars bridging the interval are jointed. (d) An adjuster is fitted like that supplied with the standard McIntyre splint. This is made easily detachable; when removed, there is freedom for knee movements. (e) A foot-piece is supplied, adjustable in position according to the length of the leg. It is pivoted on the adjusting pin, and held up by two elastic slings. Thus the foot is maintained in dorsiflexion when at rest. (f) Running wheels are attached below the foot end of the splint. These prevent friction, and allow a free excursion up and down a platform on which the splint rests.

Four pulleys are attached above the leg. These transmit four cords, two of which are attached just above, and two just below, the hinges of the splint. At their other ends are fixed counterweights (sandbags, etc.) These are not quite heavy enough to suspend the leg in the air. They merely serve to overcome most of the force of gravity. With this arrangement the patient's limited energy may be economically spent on movements at the knee, and not wasted on the purposeless act of lifting the leg from the bed.

Emphasis is laid on the importance of movements of the foot. Active contractions of the muscles of the leg stimulate the flow of blood and prevent the occurrence of œdema from venous stasis. Possibly, also, contractions of the gastrocnemii help to massage up pus from the posterior compartments of the knee-joint. The physiological method, in order to be of service, must be instituted early. It is useless to commence it when all the joint structures are becoming disintegrated by septic processes, and especially when the cartilages are becoming eroded.

In the more virulent types of inflammation, and especially when it is associated with gross bone injury, movements towards the end of the third week may become restricted and painful. It is not due to a collection of pus in the

popliteal space, it is regarded as coinciding erosion of the articular cartilages, and is the signal for the application of a rigid Thomas splint with extension, hope of a mobile knee being no longer entertained.

Such an occurrence is not to be regarded as complete failure, for experience shows that the measures adopted early have served the following purposes: (1) Prevention of tracklings; (2) Hastening of resolution of the septic processes within the joint by stimulation of the synovial circulation; (3) Limitation of the intensity of the inflammation and of toxic absorption.

Not the least striking feature when this treatment is carried out is the satisfactory general condition these patients preserve. Their appetites remain good; they sleep well; take interest in their surroundings; and, in fact, present an entirely different picture from that which we were accustomed to see when treatment by immobilization was carried out.

ANATOMICAL METHODS OF APPROACH IN OPERATIONS ON THE LONG BONES OF THE EXTREMITIES. J. E. Thompson. *Ann. Surg., Phila.*, 1918, lxviii, 309. Vol. XXIX, July, 1919, No. 1. *Surg. Gyn. and Obst.*

The author has made an extensive study of the long bones and the best routes by which they can be reached, summing up the results of this study as follows:

The best routes to expose the tibia are:

1. Along the line of its subcutaneous surface from the medial tuberosity proximally to the tip of the medial malleolus distally. This is the route of choice.

2. Along the line of the medial border of the tendo achillis and the flexor pollicis longus to expose the posterior surface of the distal end of the shaft for tendon implantation and fixation.

3. Along the line of the lateral border of the tibialis anterior to expose the anterior surface of the distal end of the shaft for tendon implantation and fixation.

To expose the fibula the best routes are:

1. Along the line of the subcutaneous surface of the lower fourth of the shaft and the lateral malleolus.

2. Along the posterior peroneal septum for the upper three-quarters of the shaft.

For the exposure of the femur, the author recommends the following routes:

1. Vertically upward from either lateral or medial epicondyle for the lower epiphysis and the lower quarter of the shaft.

2. An anterolateral incision lateral to the rectus femoris for a small area at the juncture of the middle and lower thirds of the shaft.

3. An external incision for the upper three-quarters of a shaft along a line drawn from the tip of the trochanter major to the outer border of the patella.

4. Between the vastus lateralis in front and the short head of the biceps cruris and the insertion of the glutaeus maximus behind, along a line extending from the posterior border of the great trochanter proximally to the posterior border of the lateral condyle distally.

5. Along the line of a medial incision extending vertically upward from the abductor tubercle, to expose the posterior surface of the lower fourth of the shaft (popliteal surface).

6. The anterior oblique incision lateral to the line of the upper end of the sartorius muscle for the exposure of the hip joint, the neck of the femur and the upper part of the shaft.—*Leo. C. Donnelly, Detroit.*

CURVATURES OF THE SPINE IN GROWING CHILDREN. By E. H. Bradford, M. D., Boston, Professor of Orthopædic Surgery, Harvard University Medical School. Vol. CX, No. 1, July 5, 1919, Whole No. 2118. *New York Medical Journal.*

In eight concise pages, Dr. Bradford summarizes practically all that is good concerning curvatures of the spine in growing children. The article is so concise that it does not easily permit abstracting.

The conclusions reached in many years of observation of this class of deformities may be summarized as follows:

When treatment is needed, early treatment is important.

The amount of abnormal spinal rigidity as well as the degrees of the curvatures or twists are important factors to be considered.

The method of treatment employed, whether gymnastic, corrective, or mechanical, should be used with a precise purpose and with a definite knowledge of the results obtained.

The comfort and contented coöperation of the patient is an important factor in securing the best results and, next to hygenic measures, one of the most important adjuvants in treatment.

Children with curved spines may be classed: (1) Those sitting or standing in faulty attitudes from indolence, weakness, careless habits or faulty clothing. (2) Those with changed structure in the spinal column or where such change is threatened.

The first class is helped with little difficulty or grows naturally to a normal type if in healthy surroundings. The second class needs careful examination and special treatment. In some cases an adaptation of school study period is necessary.

It is, as a rule, undesirable that the attention of young girls should be called to any peculiarities in their figure.

To determine any changes in structure of the spine, back view contour tracings alone are not sufficiently reliable. For accuracy, side view tracings should also be taken, freed from the misleading position of the movable shoulder blades.

It is always necessary to examine the movement and change in stiffness of the spinal column itself and the degree of twist if any is present.

Children do not grow evenly and they normally pass thru different stages of attitudinal habits. They tend to grow true to normal type, unless this is interfered with by ill health or unfavorable conditions.

As the variations of attitude are many the shapes of the back are correspondingly varied, but these normal varieties may be grouped as flat backs, round

backs, hollow backs, flexed backs and curved backs. These attitudinal flexible curves are so common that they cannot always be justly called pathological, as the majority correct themselves. The abnormally stiff curved backs and twisted backs are to be regarded as pathological.

To what extent the variations of the attitudinal curves are in danger of becoming pathological, i. e., exceeding the limit of normal health, is a question of opinion. This opinion should be based upon as accurate observance as possible on the probable existance of any structural change in the spinal column, indicated by abnormal stiffness as well as faulty curves and assymetrical contours.

The chief obstacles to the growth of a child of normal type without the development of structural changes are: Poor health, poor environment, rapid growth, faulty clothing and deforming occupations and habits, including an excess of seated and inactive hours.

Growing girls in good health with only slight attitudinal curves need only occasional, if any, observation.

Girls with increasing attitudinal curves and marked and increasing structional change need vigorous, thorough treatment especially if not strong.

In growing boys with flexible spinal curves, the need of treatment is dependent upon the outdoor play, activity, vigor, rate of growth and the health of the boy.

Desultory and unsystematic treatment is of little use in the correction of curves. If treatment is undertaken it should be vigorous, systematic and regular.

Growing girls should not be made unduly conscious of physical defects in shape, as there is a danger of exaggeration.

As early treatment is of great importance, mothers should periodically examine the backs of these children and be cognizant of the plain facts in regard to spinal curves. The school nurse should be well informed in the subject. The general physician can easily familiarize himself with a working knowledge which would enable him to guide the management of these cases in their growing years.

The schools can be of help. An observant teacher who watches her class should be able to classify them in A, B, C, and D groups, according to general condition, evidences of vigor, and flatchested, roundshouldered, crooked sitting and standing attitudes commonly assumed. The C classes will need careful observation and the D class thorough examination by some one well informed in the matter.

With a widely diffused knowledge of the subject and a general appreciation of the facts of the case, curvatures of the spine should disappear in our community. The school children and women would present better and stronger figures and the rank and file of our men be more upstanding.

The statistics furnished by the draft boards show that our population is physically below what it should be in our land of abundance. The soldiers returned from the training camps have taught what can be done with the average slouching street boy, farm hand and college student. Prevention is more important than cure. Curvatures of the spine are notably preventable.—*Leo C. Donnelly, Detroit.*

GUNSHOT FRACTURE OF THE FEMUR. By J. R. Buchbinder, M. D., Chicago. Vol. XXIX, July, 1919, No. 1. *Surg. Gyn. and Obst.*

We must systematically begin the treatment of such fractures with several very definite objects in view, namely: Immediate reduction and fixation; the earliest possible control of wound infection; ease of access to the thigh at all times for inspection and palpation; repeated X-ray control until bony union has occurred; a means of easily moving the patient without disturbing the fracture; and early and constant mobilization of the knee joint. It should be a cardinal rule that every fracture, regardless of its type or location, be reduced as quickly as possible, and permanent fixation applied. Mal-position of the fragments of a fracture traumatizes the soft tissues.

There are two methods of immobilizing the fragments of any fracture. The first is traction; the second, some type of fixation splint or open operation. Over-riding is an almost constant accompaniment of these fractures; neither plaster nor splints will correct this. Primary use of the Lane plate would certainly invite infection in the majority of cases. Buck's extension, its principle embodying the use of adhesive strips upon the skin upon which traction is made by means of weights and pulleys, is the method most commonly used. It is easily applied, is relatively comfortable, and in many cases it reduces the overriding, particularly in simple fractures. It is not an infrequent occurrence to discover that no amount of pull that can be safely exerted upon a Buck's apparatus, will be sufficient to correct the overriding.

The Steinman pin or so-called nail extension offers an almost ideal means comfortably and safely of maintaining accurate apposition. The original method consists of driving a nail, one-eighth of an inch thick and some inches long, thru the condyles of the femur, and making traction from the projecting ends. A more satisfactory modification consists of the "ice tongs" or "caliper," in which the nail on each side is driven merely thru the compact bone of the condyles.

When it is not necessary to do other operative work upon the thigh requiring a general anaesthesia, the caliper may be attached under local anaesthesia. The site chosen is the most superficial point of the condyle on each side. A knife puncture down to the periosteum is made, the points of the capiler inserted and then hammered into the bone about one-fourth of an inch.

Traction upon the distal fragment is absolutely certain regardless of its length. Reduction is maintained with considerably less weight than is possible with adhesive. The entire leg and thigh are free from any other incumbrances necessary for traction. The thigh is readily held clear of the bed so as freely to expose the entire posterior surface without a supporting splint or counter-traction. The patient is entirely free from any discomfort due either to traction or to the wounds made by the nail punctures. These wounds, when made thru a clean area, do not become infected.

The use of the nail extension leaves the knee comfortably mobile from the moment of its application. It has been our custom to apply to the foot of the injured side a plaster shoe extending just above the ankle. A rope imbedded in the dorsum of the shoe leads upwards over a pulley and then down to within easy reach of the patient's hand. The shoe prevents foot drop; by means of the

rope he is able easily and frequently to flex and extend the knee. A most surprising feature of this procedure is its absolute painlessness; and it assures a joint with a full range of motion when bony union has occurred.

Fractured femurs are suspended on gas pipe Bradford frames with Balkan frame attachment in such a manner that the nursing care of the patient does not disturb the fracture.

Treatment of sepsis of compound fractures is sanely discussed.—*Leo. C. Donnelly, Detroit.*

TREATMENT OF SLIGHTLY INFECTED GUN-SHOT WOUNDS OF THE JOINT. Paul Mollenhauer and Leo Mayer. *Orthopadische Chirurgie.* Vol. 38, No. 3 and 4.

The gun-shot wounds of the joint are divided in two groups

1. Those with extensive destruction of the joint and severe infection, making extensive interferences necessary. The outcome is always loss of function of the joint.

2. Gun-shot wounds of the joint with slight, usually limited, inflammation, and even an afrebile course.

It is in the latter group of cases where the question arises whether or not an operative interference is necessary at all.

The removal of the bullet is indicated in the following instances:

1. Continued increasing pain.
2. Limitation of joint motion.
3. Tedious sinus formation without tendency to healing.
4. Formation of pus and danger of joint infection.

Several cases are reported illustrating each of the points mentioned. In each case the operative technic is carefully given.

The technic of the removal of the projectile presupposes accurate localization of the foreign body. This may be carried out easily in the presence of sinuses but in other cases direct localization will meet with difficulties. During the operation it is necessary to avoid traumatizing the joint or other important anatomical structures. Regarding the approach, the trap door incision over the malleolus as approach to the talo-tibial joint has proven very satisfactory and likewise the approach thru the Tendo-Achilles to the sub-astragaloid joint.—*Arthur Steindler, Iowa City, Ia.*

CONTRIBUTION TO THE TREATMENT OF INFECTED GUN-SHOT WOUNDS OF THE HIP. Leo. Mayer. *Orthopadische Chirurgie.* Vol. 38, No. 3 and 4.

The author furnishes most interesting illustrations showing very remarkable results after severe gun-shot wounds of the hip. All cases were treated by resection of the hip, in some instances a considerable portion of the bone being removed. The author thinks that as soon as the diagnosis of superative arthritis of the hip following gun-shot wounds is made, the operation should be performed. Only in the case of other severe wounds should the exarticulation of the hip be considered.

Where the hip alone is involved there are only two alternatives:

1. Simple drainage.

2. Excision of the head and neck of the femur and of the infected part of the shaft.

In regard to the technic, in two cases a vertical incision was made behind tensor fasciae. In two other cases it was necessary to apply a curved incision. In the fifth case a long straight incision, three inches long, at the anterior bor der of the tensor fasciae sufficed.

After removal of bone the wound should be packed with gauze. A plaster paris bandage is not to be advised since traction in 20 degrees abduction with ten pound weight is sufficient. There is no need of any special apparatus.

Considering the grave prognosis of supperative hip joint contracture the results obtained by the author are really remarkable. All of the five cases reported recovered. All patients were able to walk. Four cases healed with moveable joints, some of them show a most remarkable range of motion. In only one case did the joint become ankylosed.—*Arthur Steindler, M. D., Iowa City, Iowa.*

THE SURGERY OF TENDON TRANSMISSION WITH SPECIAL REFERENCE TO THE IMPORTANCE OF THE TENDON SHEATH. By A. M. Bernstein, M. D., Vol. XXIX, July, 1919, No. 1. *Surg., Gyn. and Obst.*

The author first discusses methods of tendon transposition brought out by the earlier writers.

The general criticism of these methods is (a) that in all of them, the healthy tendon (whether anastomosed to the diseased tendon or directly implanted in its new insertion) is first isolated from its normal anatomic surroundings; and (b) that the tendon with its surrounding structures is subjected to a greater or less amount of operative traumatism; (c) that but little thought is given to the importance of a tendon being reconstituted normally as regards its working surroundings or to the pathological conditions that could and do arise as a result of the operative trauma and which interfere with the subsequent action of a transposed tendon or with its nutrition.

He next discusses the anatomy of tendons and peritendinous tissue especially discussing the work of Lovell, Tanner and Mayer. The reasons advanced by various authors for the failure of tendon transposition are discussed.

The conclusion that is fairly deducible from a study of the clinical results, appears to be that there is a general concensus of opinion that tendon transposition is a practical and valuable surgical procedure, but that none of the existing methods of performing it is entirely satisfactory as regards the functional end-results. It is also clearly seen that the occurrence of dense adhesions about the transferred tendon is one of the chief factors resulting from the operation which tends to make it a functional failure.

Consideration of these experimental findings makes it quite clear that the function of a surgically transposed tendon separated from its normal surrounding structures is interfered with (1) by disturbances of its nutrition; (2) by mechanical obstructions to its motions, i. e., adhesions; (3) by a change in the nature of its regenerated tissue. As a corollary, it would seem that the

true physiological method of transferring the function of a tendon to a new insertion is to transpose it with its necessary peritendinous structure and with the minimum amount of surgical traumatism.

In his own method of transposing the tendon with the sheath and the peritendinous tissues, a special technique is adopted. After incision of the skin and superficial fascia, the skin is retracted and the tendon in its sheath exposed to view. The tendon sheath is not opened. Where two tendons occupy the same sheath as much of the sheath is carried over with the transposed tendon as is necessary to repair the defect. Special fixation sutures are introduced at the point where the tendon is to be cut. After inserting the fixation sutures, an incision is carried laterally on both sides of the tendon for about one-fourth inch and the tendon severed. The tendon, still in its sheath, is carefully raised by means of the fixation sutures, the special object being to avoid all possible trauma by handling, etc., and a scissors cut thru the peritendinous tissue only on each side of the tendon. The isolation of the tendon is carried to the lower muscle fibers. A probe is now introduced along the paralyzed muscle, taking into account the special anatomical relation of the septum which separates the adjacent muscles, viz., the fascial planes; the probe is then carried under the ligamentary structures, as for instance, the annular ligament, and brought out at the new implantation site. The fixation suture is now attached to the eye probe and carried down thru the new canal. The transposed tendon is fixed in its new implantation. Thruout this entire operation the tendon is protected by its own normal coverings. The period of immobilization varied from 8 to 21 days after operation.

The central fact is the absence of all inflammatory processes between the tendon and the sheath, and further there is no opportunity for the occurrence of adhesions. The epitenon and endotenon remain unimpaired. Such reaction as is observed has very little effect on the functional action of the transposed tendon.

The description of the author's operation is so well illustrated that studying the illustrations renders reading the text unnecessary. — *Leo. C. Donnelly, Detroit.*

TREATMENT OF FLAIL JOINTS FOLLOWING RESECTIONS. (Traitment de laxités articulaires consécutives aux résections.) Tavernier, L., and Jalifer. *Lyon chirug.*, 1918, xv, 399.

The authors report their experience in the surgical treatment of flail-joints occurring after defective resection or resection with too free an excision of bone.

In the case of the knee, complete and solid ankylosis is absolutely necessary for the functional use of the limb; and articular laxity demands a secondary operation.

Although the authors have only operated in cases of actual flail-joint, their results have been so satisfactory that they think that every case of exaggerated laxity should be treated by metallic sutures.